THE

Sea-man's Practice,

CONTAINING

A FUNDAMENTAL PROBLEM

IN

NAVIGATION,

EXPERIMENTALLY VERIFIED:

NAMELY,

Touching the Compaſs of the EARTH and SEA, and the quantity of a Degree in our *Engliſh* Meaſures.

ALSO,

An exact Method or Form of keeping a Reckoning at SEA in any kind or manner of Sailing.

With certain *TABLES* and other *Rules* uſeful in *Navigation*: As alſo the *Plotting* and *Surveying* of *Places*: The *Latitude* of the Principal Places in *ENGLAND*: The finding of Currents at SEA, and what Allowance is to be given in reſpect of them.

By *RICHARD NORWOOD*, Reader of the *Mathematicks*.

THE THIRTEENTH EDITION.

LONDON,

Printed for *William Fiſher*, at the *Poſtern-Gate* near *Tower-Hill*; *Robert Boulter*, at the *Turks-Head*, and *Ralph Smith*, at the *Bible* in *Cornhill*, near the *Royal-Exchange*, 1678.

To the Right Honorable,

ROBERT

Earl of *WARWICK*,

Baron of *Lees*, &c.

Right Honorable,

ALthough the Knowledge and Practice of the Art of Navigation be of late years grown to a far greater perfection than it can appear to have had in any former Age; and by that means the World, and and all the parts thereof, have been further diſcovered, yea, ſailed round about; the Traffick and Intercourſe of ſeveral Nations, how remote ſo ever, facilitated; and (which, as I conceive, is of moſt importance, ſeeming as yet to be the principal ſcope of the Divine Providence in diſcovering theſe Myſteries) the light of the glorious Goſpel of Chriſt, being the mighty Power of God unto Salvation, is extended to thoſe ſilly Captives of Satan in *America*, by means of thoſe many Plantations which we have amongſt them; which Plantations (even from their firſt breathing) have received no ſmall furtherance from your Noble favour and bounty, as I know by my own experience in that where ſometimes I was, and have underſtood no leſs by others in the reſt.

Yet notwithſtanding this notable growth and daily exerciſe of the Art of *Navigation*, it ſtill remains imperfect in ſome points. For whereas the practice thereof doth eſpecially conſiſt in the knowledge of Latitudes, Courſes and Diſtances; the way of finding Diſtances at Sea, namely, by the *Log* and *Line*, is rather opinionative and conjectural, than certain; being grounded upon this Suppoſition, That the Compaſs of the World in any great Circle is 21600 *Italian* Miles (as they call them) and that ſuch an *Italian* Mile contains 1000 Paces, and every of thoſe Paces 5 *Engliſh* Feet; and according to theſe Meaſures they divide their *Log-Line*, and keep their account of the Ships way at Sea.

Having therefore by an Experiment which I made a year ſince, found more nearly the Compaſs of the Earth, and the quantity of a *Degree* on the ſame in our known Meaſures, and applied it to uſe in *Navigation*, in this Treatiſe following, and further added ſome other ſuch things as I conceived to be wanting in the Practice of that Art: I have preſumed to preſent it to your Lordſhip, as well becauſe of your knowledge in *Navigation*, and the experience you have had in your Honorable Enterprizes at Sea, you are well able to judge of it; as alſo being confident that according to your noble diſpoſition you will favourably accept thereof, though otherwiſe of it ſelf unworthy. The moſt high God, ever Bleſſed and Glorious, multiply unto your Honour all his Bleſſings in Chriſt Jeſus.

Your Honours in all due obſervance,

RICHARD NORWOOD.

To the READER.

THe Circuit of the Earth and Sea (as the Circumference of every Circle) contains 360 degr. by which degr. the diſtances thereon are meaſured, ſo that the knowledge of the quantity of ſuch a degr. in our known meaſures, is a fundamental Principle in Coſmography and Navigation, as upon which is grounded the Reckoning of the Ships way, or diſtance run. For though a Mariner being in his Voyage on the vaſt Ocean, hath ſometimes three things to certifie him where he is, and how to ſhape his Courſe to his deſired Port, namely, his Latitude, Courſe, and Diſtance; and ſometimes a fourth, namely, ſome near conjecture of his Longitude by the Variation, or otherwiſe; yet oftentimes (as in cloſe weather) he hath nothing but his Courſe and Diſtance; otherwhiles only his Latitude and Diſtance is his chief guide in falling in with his intended Port. I know it is uſual to allow near 7 Fathoms or 41$\frac{2}{3}$ Feet to a Knot, and ſo many of thoſe Knots as run out in half a Minute, ſo many Miles they account the Ships way to be in an hour. And if in half a min. ſhe run 41$\frac{2}{3}$ Feet, then in 60 min. or an hour, ſhe runs 5000 Feet; and thus they account 5000 Engliſh Feet, or 1000 Paces to be a Mile, and 60 of thoſe Miles to be a degr. ſuch as the whole Circumference in any great Circle is 360. But how is this known to be true? If it be anſwered, that it is known to be ſo by Experience; then I would know further by what Experiment this was found to be ſo? Where, and by whom made? I preſs this ſo much the rather, becauſe I am perſwaded we have at this day as many excellent Navigators in this Kingdom, and as great Voyages performed, as from any other place in the World; and I ſhould be glad to hear of the experimental reſolution of this Problem by ſome of them, though it were but in running 8 or 10 degr. near the Meridian: for ſo I doubt not but that which I have here written thereof, would receive further confirmation, and better entertainment, than happily it will now, being ſo much different from the common opinion, and the Arts of Navigation and Coſmography, would be much more perfected in ſhort time. For one Error (as a fruitful Mother) is oftentimes the cauſe of more, and ſo the removing of one is the occaſion of removing others, eſpecially when they do mutually ſupport one another. As we ſhall here ſhew how the Error in the projection and uſe of the common Sea-Chart, is ſupported by this Error of accounting only 300000 of our Feet to a Degree; and this in like ſort upheld by that, ſo that they will ſtand or fall together. And ſurely that had fallen long ſince, being ſo manifeſtly convinced, if it had not been upheld by this. For the

confuting

confuting of that (I mean the common Sea-Chart) it was ſufficient to know that the Earth and Sea make one Spherical Body, but in diſproving and rectifying this, it is neceſſary to know moreover what is the quantity of that Spherical Body: And to that end, it was neceſſary to make a ſenſible application of our known Meaſures to a determined part of the whole, that ſo the quantity of that determined part being known, and the proportion thereof to the whole, the quantity of the whole might alſo be diſcovered. And this I have endeavoured in the Experiment following, which if I have not handled ſo exactly in all points as ſome would deſire (that requiring more time and charge than I could well beſtow) yet I doubt not but it will be found that I have come very near the Truth. Some happily will cenſure me for being my ſelf at the expence to make ſuch an Experiment: But I was as frugal in it as I could, adding pains and induſtry to ſave expence; I came up in ten or eleven days, and had other neceſſary occaſions to lead me from the one place to the other, and did this as a thing falling opportunely in my way: But indeed (as in all other parts of Learning) ſo in the Mathematicks, eſpecially in their application, or middle Mathematicks (as ſome call them) it is neceſſary, with Speculation to joyn actual and experimental Practices; the former being empty and uncertain without theſe. It is true, that the Mathematicks afford large Fields of delightful Speculations, wherein a man might walk far with much pleaſure: But if from ſo many fair Flowers, he bring home no Honey, or from ſuch large Fields no Sheaves; I mean, if he bring not thoſe Speculations to ſome uſeful Practices, neither himſelf nor others are like to receive much fruit by them. But this indeed cannot be effected without more labour and difficulty; yet ſometimes it requires Mechanical and Bodily exerciſes, which ſome eſteem too mean and unworthy to ſtoop unto. But for mine own part, I acknowledge to have had my living and maintenance by the Mathematicks, and not by Speculation only, but rather by my practice therein; and therefore alſo I deſire (what in me lies) to make them fruitful to my ſelf and others; and to that end have ſpent in ſome principal parts of the Mathematicks, near as much time and means in experimental Practices and Concluſions, as in the Speculations. Moreover, conſidering that this particular Experiment was propoſed above 30 years ſince, by our Country-man Mr. Edward Wright, to invite ſome to the tryal of it, as a thing which he would have done himſelf, if he had found ſuch furtherance and opportunity as he deſired, which it ſeems he did not, nor any other ſince that time. Rather than ſo noble and ſo neceſſary a Problem ſhould longer reſt unreſolved, I took the opportunity offered, hoping it may be an occaſion to whet on ſome others to do the like. This, with ſome other things which I conceived to be wanting in the practice of Navigation, I have handled in this enſuing Treatiſe, which I commend to your friendly acceptance. Farewel.

July the firſt, 1636.

THE

THE SEA-MAN'S PRACTICE.

CHAP. I.

The common Opinion touching the Compaſs of the Earth, and quantity of a Degree of the ſame.

IT is a common received Opinion in *England* (and the like is in other places) that allowing 5 of our *Engliſh* Feet to a Geometrical Pace, 1000 of thoſe Paces make an *Italian* Mile, and 60 of thoſe Miles in any great Circle upon the Spherical Surface of the Earth and Sea, make a Degree; and thus it is ſuppoſed, that a Degree contains 60 Miles, or 60000 Paces, or 300000 of our *Engliſh* Feet, and by ſuch Miles do Mariners in their Voyages by Sea keep their Reckonings. And becauſe the whole Circumference of a Circle is 360 Degrees, therefore the compaſs of the Earth, according to this Opinion, ſhould be 21600 ſuch *Italian* Miles, or 21600000 Paces, or 108000000 of our *Engliſh* Feet. Whence this Opinion came, or upon what Experiment it ſhould be grounded, I cannot certainly ſay: It may ſeem to be taken, or rather miſtaken from *Ptolomy*, who ſaith, there are 500 *Stadiums* in a Degree; the ſame was before affirmed by *Martinus Tyrius*, of whom *Ptolomy* ſpeaking in the 11*th* Chap. of his firſt Book of *Geography*, hath theſe words, *Sed in hoc quoque rectè ſentit, partem unam qualium eſt circulus maximus trecen-*

trecentorum ſexaginta, quingenta in terra conſtituere Stadia, id enim confeſſis dimenſionibus conſonum exiſtit. Now a *Stadium* not only amongſt the *Greeks*, but as appears by *Herodotus*, amongſt all other Nations of *Aſia*, and in *Egypt*, did conſiſt of 600 Feet, or 100 *Orgya's*, an *Orgya* containing 6 Feet or 4 Cubits, as our Fathom doth; the ſame alſo is teſtified by *Suidas* and others: So that a Degree containing 500 *Stadium's*, and every *Stadium* 600 Feet, it follows that a Degree muſt contain 300000 Feet, exactly agreeing in number with the common received opinion in *England*, which therefore may ſeem to be hence derived, and would alſo receive much confirmation hereby (he being an Author of ſuch approved credit) if it could be approved that our *Engliſh* Feet were exactly equal to the *Egyptian* or *Alexandrian* Foot, where *Ptolomy* wrote. Otherwiſe that being true, that ſo many of their Feet make a Degree, it will follow, that if ours be greater, there be fewer of them contained in a Degree; if leſſer (as undoubtedly they are) there muſt be more of them contained in a Degree.

Philander, in his Commentary upon the third Chapter of the third Book of *Vitruvius*, hath expreſſed the quantity of the ancient *Roman* Foot, where (by a competent allowance for the ſhrinking of the Paper, being printed wet) it may probably be gathered that it was ſomething longer than our *Engliſh* Foot. But the *Alexandrian* and *Egyptian* Foot was much greater; for according to *Hero Mechanicus*, 5 *Alexandrian* Feet were equal to 6 *Roman* Feet: ſeeing the ancient *Roman* Foot was ſomething greater than ours, the *Alexandrian* muſt needs be much greater than ours. So that whereas *Ptolomy* ſaith there are 500 *Stadium's* in a Degree, and as we have ſhewed a *Stadium* did conſiſt of 600 Feet, theſe being *Egyptian* or *Alexandrian* Feet, as it is moſt probable, being the place where *Ptolomy* lived; there muſt be a far greater number of our Feet in a *Stadium*, and ſo in a Degree: whence it is evident that there is no ſufficient footing for this common opinion in the aſſertion of *Ptolomy*.

Neither doth the Practice and Experiment of Mariners in their Voyages at Sea prove it; for there is no Reckoning or Experiment at Sea ſet down by any (that I have ſeen) to confirm it. And though it be true, that in ſailing between two places that lye near to one and the ſame Parallel, they ground their Reckoning chiefly upon this

ſuppoſition, that 300000 of our *Engliſh* make a degree, yet can they ſeldom or never by thoſe reckonings diſcern the Error, the rather for that they have been, and for the moſt part are ſtill kept upon the Plain or Common *Sea-Chart*, which makes a degree in any Parallel equal to a degree in the Equinoctial, and ſo makes a degree in any Parallel to contain 300000 Feet: And it is true, that in ſome Parallel a degree doth contain only 300000 of our *Engliſh* Feet; namely, about that Parallel which is in Latitude 35 degrees (as we ſhall further ſhew hereafter) near unto which have the principal of our Eaſtern and Weſtern Voyages been made. And thus, though this opinion of 300000 Feet in a degree, and the Projection of the Common *Chart* be both erronious; yet becauſe the Error of the one doth ſomething ſalve the other, they could not be ſo eaſily diſcern'd by Experience only.

This opinion of 300000 *Engliſh* Feet to a degree, may ſeem alſo to be ſomething confirmed by an obſervation made by our Country-man Mr. *Edward Wright*, upon Mount *Edgecomb* near *Plymouth*, of the Semi-diameter of the Earth, which he hath ſet down in his Book, *Of the Correction of Errors in Navigation*, Chapter 15. where he finds the Semi-diameter to be 18312621 of our *Engliſh* Feet, whence it may be gathered, that in a degree of a great Circle of the Earth, there ſhould not be full out 320000 of our Feet; but the way by him then uſed, though it was very fit for the end whereunto he there applies it; namely, to find the dipping or depreſſion of the apparent Horizon beneath the true, according to the height of the Eye above the Water; yet it will eaſily be granted to be no exact way for finding the Semidiameter, and conſequently the Circumference of the Earth, or the quantity of a Degree on the ſame; and ſo he ſays there, that he uſed that way, becauſe he wanted opportunity to put in practice a more exact way. Wherefore for the further ſatisfaction of my ſelf and others in this Point, and chiefly for the neceſſary uſe it hath in the Practice of *Navigation*, I have made the experiment following, that ſo the quantity of a degree, and of the whole Compaſs of the Earth, might at leaſt-wiſe be nearly known in our *Engliſh* Meaſures.

CHAP. II.

An Experiment made for finding the quantity of a deg. *and ſo the Circumferences of the Earth and Sea in our known Meaſures.*

HAving occaſion to be in the City of *York*, about the beginning of *June*, *Anno*, 1635. I made there ſeveral Obſervations of the Meridian Altitude of the Sun, the laſt of which was made the 11*th* of *June*, the Skie was every of thoſe days ſomething overcaſt at Noon, yet not ſo much but that an Obſervation might be made to a near ſcantling: And becauſe the laſt of thoſe Obſervations is moſt fit for the preſent occaſion, and that day was as clear as any of the other, we will here eſpecially make uſe of that, being as followeth.

Upon the 11*th* of *June*, 1635. I made an Obſervation near the middle of the City of *York*, of the Meridian Altitude of the Sun, by an Arch of a *Sextant* of more than 5 Foot Semidiameter, and found the apparent Altitude of the Sun that day at Noon to be 59 deg. 33 min.

I had alſo formerly upon the 11*th* day of *June*, *Anno* 1633. obſerved in the City of *London*, near the Tower, the apparent Meridian Altitude of the Sun, and found the ſame to be 62 deg. 1 min.

And ſeeing the Suns Declination upon the 11*th* day of *June*, 1635, and upon the 6*th* day of *June* 1633, was one and the ſame, without any ſenſible difference; and becauſe theſe Altitudes differ but little, we ſhall not need to make any alteration or allowance, in reſpect of Declination, Refraction, or Parallax: Wherefore Subtracting the leſſer apparent Altitude; namely, 59 deg. 33 min. from the greater 62 deg. 1 min. there remains 2 deg. 28 min. which is the difference of Latitude of theſe two Cities; namely of *London* and *York*.

Alſo by the aforeſaid Obſervation made in *York*, it appears that the Latitude of that City is 53 deg. 58 min. almoſt.

But

But to our purpoſe; coming at that time from thence to *London*, I further found by Meaſure, that the Parallel of *York* is from the Parallel of *London* 9149 Chains; every Chain being 6 Poles, and every Pole $16\frac{1}{2}$ of our *Engliſh* Feet; that is, every Chain 99 Feet. (After what manner I found this to be ſo, we ſhall further expreſs hereafter:) But thus, as I ſay, I found that *York* is more Northerly than *London* by 9149 Chains: And before we have noted that theſe two places differ in Latitude 2 deg. 28 min. therefore it follows, that 2 deg. 28 min. of the Meridian of the Earth and Sea, is equal to 9149 Chains. And if accordingly we would know how many of theſe Chains are contained in 1 deg. we may find that by the Rule of Proportion, firſt reducing the degrees into Minutes; and then ſay,

If the difference of Latitude	148 *co. ar.*	7.82974
give ſuch a number of Chains.	9149	3.96137
Then 1 Degree, that is	60	1.77815
gives of ſuch Chains	3709	3.56926

and ſomewhat more, namely, 5 Feet, which reduced into Feet make 367196; that is, 367200 Feet in a degree, lacking 4 Feet, which here we regard not.

Thus then, according to this Experiment, it is evident, that one degree of a great Circle meaſured on the Earth is near 367200 Feet, which in our Poles of $16\frac{1}{2}$ Feet, is 22254 Poles, and about one half; and theſe reduced into Furlongs, at 40 Poles to the Furlong, make 556 Furlongs and 14 Poles: and laſtly, theſe reduced into our *Engliſh* Miles, of 8 Furlongs to a Mile, make 69 Miles, and 4 Furlongs 14 Poles, that is, $69\frac{1}{2}$ Miles and 14 Poles in a Degree.

And hence, according to the moſt approved *Hypotheſis* of the Sphericity of this Terreſtrial Globe, we may find the Compaſs of it as followeth. But firſt, you may Note that we ſpeak not here of the Compaſs of the Earth in any Parallel, or leſſer Circle deſcribed upon any ſide thereof, that being various (according to the different diſtance of thoſe Circles from their Poles) but of the Compaſs taken in the middle or greateſt thickneſs of the Globe; namely, in any great Circle, ſuch as divide the whole Globe into two equal parts, of which kind are the Equinoctial

and all Meridians, *&c.* this being properly the *Perimeter* or *Compaſs* of a *Spherical Body.*

Now ſeeing a degree is the 360 part of the Circumference of a Circle (for any Circumference being divided actually or by ſuppoſition into 360 equal parts, thoſe parts are called Degrees) if we can find how many Feet, Paces, Miles, or other known meaſures are contained in one of thoſe degrees, then ſhall we eaſily conclude how many of the ſame known meaſures are contained in the whole Circumference: But by the former Experiment we find, that in one deg. of a great Circle on the *Spherical Superficies* of the Earth there is contain'd 367200 Feet; therefore it is evident that 360 times 367200 Feet is the Compaſs of the whole; wherefore multiplying 367200 by 360, the Product is 132192000 Feet, which reduced into Poles is 8011636; and theſe reduced into Furlongs, are 200290 Furlongs 36 Poles: and laſtly, theſe reduced into Miles are 25036 *Engliſh* Miles, and ſomewhat more, for the Circuit of the Earth and Sea.

If further we deſire the Diameter and Semidiameter of the Earth: Foraſmuch as it is proved by *Archimedes*, that the proportion of the Circumference of a Circle is the Diameter thereof, almoſt as 22 to 7: Therefore by the Rule of Proportion, as 22 to 7, ſo is the Circumference of the Earth to the Diameter thereof: So that multiplying the Circumference of the Earth, namely, 132192000 Feet by 7, and dividing the Product, namely, 925344000 by 22 the Quotient, namely, 42061090 is the Diameter of the Earth in Feet, the half whereof, namely, 21030545 Feet is the Semidiameter of the ſame, being 21 millions of Feet, and ſomewhat more: theſe reduced into *Engliſh* miles, as before we did the Circumference, ſhew the Diameter of the Earth to be 7966 miles, and ſomewhat more, and the Semidiameter 3983. And thus we have the Circumference, Diameter, and Semidiameter of the Earth, as alſo the Quantity of a degree of the ſame Circumference in the known meaſures of Feet, Furlongs, and Miles, *&c.* There are only two things here, which may ſeem doubtful; namely, the Experiment it ſelf, and the *Hypotheſis* of the Sphericity of this *Terreſtrial Globe*, conſiſting of the Earth and Sea; for theſe being admitted, the meaſures thence reduced as before, will neceſſarily follow.

Now

Now touching the Experiment; I confeſs, that to have made it ſo exact as were requiſite, and in all Points, ſo as I ſhall ſhew in the Chapter following, would have required much more time and expence than mine ability would reach unto; Yet having made obſervation at *York*, as aforeſaid, I meaſured (for the moſt part) the way from thence to *London*; and where I meaſured not, I paced; (wherein through Cuſtom I uſually come very near the truth) obſerving all the way as I came, with a Circumferentor all the principal Angles of Poſition or Windings of the way (with convenient allowance for other leſſer Windings, Aſcents and Deſcents,) and theſe I laid not down by a Protractor after the uſual manner, but framed a Table much more exact and fit for this purpoſe, as we ſhall hereafter ſhew; ſo that I may affirm the experiment to be near the truth.

Touching the *Hypotheſis*, that the Earth and Sea make one Spherical or round Body, it is generally agreed upon by all the principal Philoſophers, Aſtronomers, Geographers, and Navigators, Ancient and Modern: Some reaſons demonſtrative, for the affirmation thereof, may be theſe.

Firſt, the Eclipſes, eſpecially of the Moon, which are cauſed by the ſhadow of the Body of the Earth, being interpoſed between the Sun and the Moon; and foraſmuch as this ſhadow doth fall upon the Moon, always and upon every ſide Circular, and ſo appears to us, it is manifeſt by the Opticks, that the Earth from whence it proceeds is a Spherical Body.

Secondly, likewiſe the Eclipſes of the Sun, which are cauſed by the interpoſition of the Moon between the Sun, and thoſe places where it appears Eclipſed; I ſay, it could not be determined when, and in what place ſuch an Eclipſe ſhould appear, and where not, if the form of the Earth were not known: but ſeeing the places where ſuch Eclipſes happen, and where not, may be, and are uſually determined and that upon this Ground, that the Surface of the Earth is Spherical, it is thence alſo ratified to be a truth.

Thirdly, the Sun, Moon, and Stars, do riſe and ſet, and are upon the Meridian ſooner to thoſe that are reſident in the Eaſtern parts, than to others more Weſterly, and that in a proportion anſwerable to the roundneſs of the Earth, as the Planets and Stars are

upon

upon our Meridian at *London* ſooner by almoſt 4 hours, than they are to thoſe that inhabit the *Summer Iſlands*, and the confines of *Virginia* and *New England:* And ſo in *Eaſt-India*, and other Eaſtern Regions, the Sun and Stars are ſooner upon their Meridian than upon ours; which is manifeſt to be ſo, as by other reaſons, ſo eſpecially by the Eclipſes of the Moon: for an Eclipſe of the Moon hath not in it ſelf any diverſity of time, being at one and the ſame inſtant without reſpect of places, yet becauſe in the Eaſtern parts the day is begun, and it may be far ſpent before it begin in places far Weſterly, therefore ſuch an Eclipſe may appear to the Eaſtern Inhabitants toward the end of the night, which to the Weſtern appears in the beginning or middle of the ſame night with them, and ſo the difference will be more or leſs, according to the different diſtance of thoſe places in Longitude.

Fourthly, Furthermore we ſee, that going or Sailing to the Northwards, we have the Artick Pole and Southern Stars more elevated, and the Antartick Pole and Southern Stars more depreſſed, the Elevation Northerly increaſing equally with the depreſſion Southerly, and either of them proportional to the Diſtances which we go: The like happeneth in going to the Southwards. Beſides the Oblique Aſcenſions, Deſcenſions, Occultations, Emerſions, and Amplitudes of Riſing and Setting of the Sun and Stars, in every ſeveral Latitude, agreeable to the *Hypotheſis* of the Earth's Sphericity; All which could not be ſo, if the Earth were of any other than of a Spherical form.

Fifthly, So if we ſtand upon the Sea-ſhore, and ſee a Ship far off under Sail, making towards the Land, at firſt we ſee only the Top-Sails or higheſt parts, and withall do manifeſtly behold the Convex Superficies of the Sea, as it were raiſed and interpoſing her ſelf between our ſight and the Hull, or lower parts of the Ship, till ſhe approacheth nearer, and this uniformly, every ways alike, and proportionably to the ſeveral Diſtances; which doth evidently demonſtrate the Spherical roundneſs thereof.

Sixthly, And laſtly, (to add no more) the Navigations of theſe later time make it apparent, thoſe eſpecially that have been made round about the World, as thoſe two Voyages by our famous Country-men Sir *Francis Drake*, and Mr. *Thomas Candiſh*, both which ſeverally Sailing from our Coaſts to the *Weſt-Indies*, and paſſing the Straits

Straits of *Magellane*, continued their Course Westerly, till they came into those parts, which are from us to the Eastwards, namely, to the *East-Indies*, and so Sailed still Westerly till they came to *Cape bon Esperance*, and thence returned into *England*: Having Sailed about the whole Terrestrial Globe, they found nothing by their Observations or Reckonings dissonant from the uniform *Sphæricity* thereof in all its parts. That they came short in the number of days, one, or reckoned the time of their absence less by one day and a night than they which remained at home; this further confirms the thing in hand.

Yet whilst we speak here of the Roundness of the Earth and Sea, we intend it not so strictly as if it were a thing turned round without any inequality to its Superficies: But as a Bowl or Ball, though it hath some dust or small grains of Sand cleaving thereto, may still be said to be round: So, though the Land, Hills, and Mountains be somewhat raised above the Spherical Superficies of the Sea; and if there should be also some Valleys or Bottoms more depressed; yet seeing the greatest of these inequalities have scarce any sensible proportion of the whole, we may well affirm the whole to be round.

The Relations made of the Prodigious height of some Mountains, as to be 60 or 70 Miles high, if it be understood of their perpendicular or direct height, are fabulous; the Mount *Atlas*, Recorded by some of the Ancients to reach up almost to the Moon, and to be as it were, a Pillar for the Heavens to rest upon, being measured Geographically by *Eratosthenes*, the perpendicular or upright height from the top thereof to the Valleys beneath, was found not to exceed 10 *Stadiums*, which of our *English* measures is little more than a Mile and a quarter, a *Stadium* not much differing from our Furlong; and the like might be shewed of others.

But if we admit the highest Mountain to rise perpendicularly above the Spherical Superficies of the Sea 2 Miles; yet seeing the Diameter or whole thickness of the Earth, is, as we have before shewed, 7966 Miles, this exorbitancy or difference of 2 Miles is of small moment; yea, if there were any Mountain 8 Miles in height upright, yet this compared with the whole thickness of the Earth, is little more than one thousand part thereof, therefore

we may conclude, that this *Terreſtrial Globe*, conſiſting of the Earth and Sea, is *Spherical*. We come in the next place to ſhew by what way of meaſuring we found the Parallel of *York*, to be diſtant from the Parallel of *London*, 9149 Chains. And ſo how the diſtance of the Parallel of two places may be exactly meaſured.

CHAP. III.

A moſt exact way for finding the quantity of the Diameter and Circumference of the Earth and Sea, and of a Degree on the ſame.

I Do the more fully ſet down the way of making this Experiment, that ſo I may give occaſion to any who are ſo Nobly minded for a Publick good, as to be at that Charge to make a farther and more exact tryal thereof. Now then, the beſt and perfecteſt way is, to obſerve ſo exactly as may be, the Summer *Solſtitial Altitudes* of the Sun at two places, ſo far diſtant aſunder, and lying ſo near North and South each from other, with ſo direct and fair a way betwixt them, as conveniently may be choſen: Suppoſe for Example, *Chriſt-Church* and *Berwick*, or ſome other place in the fartheſt parts of *Scotland*, for the farther theſe two places are each from other, the more perfectly may this buſineſs be performed. Then meaſure as truly as is poſſible, and ſet down in a Book all the way between thoſe two places, with all the Windings, Aſcents and Deſcents that are therein, whereby with the help of the enſuing Table, you may eaſily and exactly find how much the one place is more Southerly than the other. For this purpoſe the plain Table is not the fitteſt Inſtrument, or rather a *Theodolite* or *Peractor*, or ſome other of that kind, obſerving diligently the Variation of the Needle. The Chain may be 6 Poles long, or rather 100 Feet, and the Table fitted accordingly (but the Table following is for Poles) if it ſhould be much longer, it would be too heavy.

The High-ways are commonly crooked; yet becauſe of ſundry obſtacles and impediments which are incident out of the way, and becauſe

becauſe a man cannot certainly at firſt direct himſelf the neareſt and beſt way to the place intended, it would be expedient to meaſure the Diſtance as aforeſaid; Firſt, in the High-ways leading from the one to the other, and then in the neareſt and beſt way that could be choſen between them; and ſo if any notable Error happen in the one, it may be diſcover'd and amended in the other. The form which I obſerved in ſetting down the meaſures and Angles, was according to this Example.

Deg.		*Diſtance.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
S E	31					
S E	20					
S E	13					
S E	13					
S W	02					
S E	05					

It is to be underſtood, that the Table here following was before Calculated to ſerve inſtead of a *Protractor*, for a *Circumferentor*, or other Graduated Inſtrument, and for a Chain of 3 Poles, which for the moſt part I uſe; yet it may very well be applied to a Chain of 6 Poles, (as in this buſineſs it was) reckoning every Chain to be two, *&c.* And thus for every ten Chains of ſix Poles to a Chain, I make two Strokes, ſignifying 2 Changes or 20 Chains; and if there be any odd Chains, for thoſe I ſet a Figure in another Line next below, and if moreover any odd Poles, whether one or two, for thoſe I ſet another Figure in the third Line below.

Thus the laſt entrance before-going, being *S E* 05 *degrees*, ⫶ ſignifies that the Line upon which I went, was from the South part of the Meridian to the Eaſtwards, making an Angle with the Meridian of 5 deg. the 9 Strokes ſignifie 9 Changes, or 90 Chains; the Figure 5 ſignifieth 5 Chains, and the Figure 2, two

Poles. So that it is to be read thus, South-Eaſterly 5 Degrees, 9 Changes, 5 Chains, and 2 Poles; and the like is to be underſtood of the reſt. But for the moſt part having liberty of Ground, I end the meaſure of every Line, either with a whole number of Changes, or at leaſt of Chains.

And thus proceeding all day, towards the Evening, or when elſe I have time convenient, I reduce all theſe Diſtances, upon what Lines or Angles ſoever they be, to Diſtances North or South, Eaſt or Weſt, as here appears.

Deg.		*Diſtance.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
				2571	1545	
S E	31	0		2819	1026	
S E	20			1692	616	
		6		0169	062	
S E	13			2923	675	
				1754	404	
S E	13	0		1499		052
S W	02	0		2690	231	
S E	05	5 2		0149	013	
				0020	002	
Chains.		571		16287	4578	052
		2		0	52	
Poles.		1715		16285	4525	

We will explain the laſt, and ſo the reſt may eaſily be underſtood; *S E* 5 deg. 5. 2. Here becauſe I have *S E.* the numbers taken out of the Table muſt be put in the Columns entituled *South* and *Eaſt.* Then in the Table under 5 deg. I look for 9 Changes, and find againſt it 2690, and in the adjacent Column under the Complement thereof 235, and becauſe *S E* 5 deg. is leſs than 45 deg. that is, nearer to the South than to the Eaſt. I put in the Column entituled South 2690, and in that entituled Eaſt 235, then again in the ſame Tabular Column under 5 deg. I find againſt 5 Chains (cutting off a Figure, becauſe 5 Chains

Chains is but the tenth part of 5 Changes) 149 to be put in the South Column, and 13 for the East Column.

Lastly, Against 2 Poles I find for the South Column 20, and for the East 2; and the like is to be understood of all the rest.

Now supposing this last to be a place, whose Distance and Scituation from the first is required; I sum up the Columns severally, and of the North and South Columns Subtract the lesser from the greater, and so of the East and West Columns; and so it will appear how much North or South, and how much East or West the last place is from the first.

As in this Example, we find the last place to be the Southwards of the first 1628 Poles, for the last Figure may be cut off, being used in the Table, only for the more exactness, or may be made a Fraction, and so it is 1628 $\frac{6}{10}$ Poles; Likewise, the last place is to the Eastwards of the first 452 $\frac{6}{10}$ 5 Poles; and thus I proceed all the way.

Now touching the Angles of Ascent and Descent of Hills and Valleys, to have observed them exactly, would have required more time and charge than I could of my self bestow, yet I made allowance for such of them as were of most moment; He that would observe them all, may either make 2 or 3 Columns more, or keep an account of them apart by themselves. But if he intend no farther use of them, but to find the neareſt distance, he need not set them down, but make allowance for them on the Ground, keeping his Distance intire without Fractions.

As, admit I observe the Ascent from a Valley to the brow of a Hill to be 14 deg. above the Level or Horizontal Line, and that measuring, I find the Distance to be 30 Poles; I turn to the Table, and under 14 deg. and against 10 Chains, I find 2911, and 726, shewing that the Level or Horizontal Distance from my Station, to that brow, is only 29 $\frac{11}{100}$ Poles, and that the height of that brow above the Level Line, is 7 $\frac{44}{100}$ Poles: But finding thus that the *Hypothenusal* being 30, the Base or Level Line is but 29 $\frac{11}{100}$, that is less by $\frac{89}{100}$, because I would avoid this Fraction, I add to the end of the foresaid measure of 30 Poles upon a Level Line, $\frac{89}{100}$ of a Pole, and then I may account my self distant from the place in the Valley where I made Observation, 30 Poles in a Level or Horizontal Line, and so set down the Distance without a Fraction: the like is to be understood of all other Ascents and Descents.

Here followeth the Table.

	1 d.	89 d.	2 d.	88 d.	3 d.	87 d.	4 d.	86 d.	5 d.	85 d.
1	300	5	300	10	300	15	299	21	299	26
2	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	598	63	896	79
4	1200	20	1200	42	1198	62	1198	84	1195	105
5	1500	26	1500	53	1497	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2099	74	2097	110	2095	14[illegible]	093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2698	95	2696	140	2694	18[illegible]	2690	235
10	3000	52	2998	105	2996	157	2993	210	989	262
1	10	00	10	0	10	0	10	1	10	1
2	20	00	20	1	20	1	20	1	20	2

	6 d.	84 d.	7 d.	83 d.	8 d.	82 d.	9 d.	81 d.	10 d.	80 d.
1	298	31	298	37	297	42	296	47	295	52
2	597	62	596	74	594	84	592	94	590	104
3	895	94	894	111	891	125	889	140	887	156
4	1193	126	1192	146	1188	167	1185	187	1182	208
5	1492	157	1489	183	1485	209	1481	234	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2080	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2364	417
9	2686	283	2680	329	2674	376	2667	422	2659	469
10	2984	314	2978	366	2971	418	2963	469	2954	521
1	10	1	10	1	10	1	10	1	10	1
2	20	2	20	2	20	3	20	3	20	3

	11 d.	79 d.	12 d.	78 d.	13 d.	77 d.	14 d.	76 d.	15 d.	75 d.
1	295	57	293	62	292	67	291	73	290	78
2	590	114	586	124	584	134	582	146	580	156
3	883	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	270	1164	290	1160	310
5	1473	286	1467	312	1461	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	466
7	2060	401	2055	436	2047	472	2038	508	2030	543
8	2355	458	2348	500	2359	540	2329	580	2320	621
9	2650	515	2641	562	2651	608	2620	653	2610	699
10	2945	572	2934	624	2929	675	2911	726	2898	776
1	10	2	10	2	10	2	10	2	10	3
2	19	4	19	4	19	4	19	4	19	5

	16 d.	74 d.	17 d.	73 d	18 d.	72 d.	19 d.	71 d.	20 d.	70 d.
1	288	83	287	88	285	93	284	98	282	103
2	576	166	574	177	570	186	568	196	564	203
3	865	250	861	264	855	279	851	294	846	308
4	1153	332	1148	352	1140	371	1135	91	1128	411
5	1442	413	1434	438	1426	463	1418	488	1410	513
6	1730	496	1721	526	1711	556	1702	586	1691	616
7	2019	580	2008	615	1997	649	1986	684	1937	719
8	2307	663	2296	703	2282	743	2270	782	2255	822
9	2596	746	2582	791	2567	836	2552	880	2537	924
10	2884	827	2869	877	2853	926	2836	977	2819	1026
1	10	3	10	6	10	3	10	3	10	6
2	20	5	19	3	19	6	19	6	19	3

	21 d.	69 d.	22 d.	68 d.	23 d.	67 d	24 d.	66 d.	25 d.	65 d.
1	280	107	278	112	276	117	274	122	272	127
2	566	215	556	224	550	234	548	244	544	254
3	840	322	834	337	828	351	822	366	816	381
4	1120	429	1112	449	1104	468	1096	488	1088	508
5	1400	537	1391	562	1380	586	1370	610	1360	634
6	1680	645	1669	674	1656	703	1644	732	1632	761
7	1960	752	1947	786	1932	820	1918	854	1904	888
8	2240	860	2025	899	2209	937	2192	976	2175	1015
9	2521	968	2504	1011	2485	1054	2466	1098	2447	1142
10	2801	1075	2782	1124	2761	1170	2740	1220	2719	1268
1	9	7	9	4	9	4	9	4	9	4
2	18	4	18	8	18	8	18	8	18	8

	26 d.	64 d.	27 d.	63 d.	28 d.	62 d.	29 d.	61 d.	30 d.	60 d.
1	270	131	267	136	265	141	262	145	260	150
2	540	263	534	272	530	282	524	290	520	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1068	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1559	900
7	1888	1918	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1127	2098	1162	2079	1200
9	2427	1282	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1285	2673	1362	2646	1408	2624	1454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	18	18	10	18	10	18	10	18	10

	31 d.	59 d.	32 d.	58 d.	33 d.	57 d.	34 d.	56 d.	35 d.	55 d
1	257	154	254	159	252	163	249	168	246	172
2	514	309	508	318	504	326	498	336	492	344
3	773	463	763	477	755	489	747	504	738	516
4	1028	617	1017	636	1007	653	995	671	983	688
5	1285	772	1272	795	1258	817	1243	838	1228	860
6	1542	927	1526	954	1510	980	1492	1006	1474	1032
7	1809	1081	1780	1113	1762	1144	1741	1174	1720	1204
8	2057	1235	2034	1272	2013	1307	1990	1342	1966	1377
9	2314	1390	2288	1431	2265	1470	2238	1510	2212	1549
10	2571	1545	2544	1590	2516	1634	2487	1677	2457	1711
1	9	5	8	5	8	5	8	6	8	6
2	18	10	16	10	16	10	16	12	16	12

	36 d.	54 d.	37 d.	53 d.	38 d.	52 d.	39 d.	51 d.	40 d.	50 d
1	243	176	240	180	236	185	233	189	230	193
2	486	352	480	360	472	370	466	378	460	386
3	729	528	720	541	709	555	699	567	690	578
4	971	705	960	721	945	739	932	756	920	771
5	1213	881	1198	902	1182	923	1165	944	1149	964
6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
9	2185	1586	2157	1624	2126	1663	2094	1700	2069	1735
10	2427	1763	2396	1805	2364	1847	2331	1888	2298	1928
1	8	6	8	6	8	6	8	6	8	6
2	16	12	16	12	16	12	16	12	16	12

	41 d.	49 d.	42 d.	48 d.	43 d	47 d.	44 d.	46 d.	45 d.	45 d.
1	226	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	905	788	892	803	878	819	864	833	849	849
5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1584	1371	1560	1406	1535	1433	1511	1458	1485	1485
8	1810	1575	1783	1607	1754	1638	1727	1666	1697	1697
9	2836	1772	2006	1807	1974	1842	1943	1874	1910	1910
10	2264	1968	2229	2007	2194	2046	2158	2084	2122	2122
1	8	7	7	7	7	7	7	7	7	7
2	16	14	14	14	14	14	14	14	14	14

The Structure of the Table is from this ground:

As *Radius* is in proportion to the Distance of two places measured in their Rumb; so is the Sine of the Complement of that Rumb, to the difference of the Latitude of the two places.

And so is the Sine of the Rumb, to the distance of the Meridians of those two places. As, admit I measure South-Easterly 20 *deg.* 31 Poles, here then the Rumb upon which I measure, making with the Meridian an Angle of 20 *deg.* I say,

As *Radius* is in proportion to the Distance measured, 300 Poles;	2.47712
So is the Sine Complement the Rumb, S E 20 *deg.*	9.97299
to the Difference of Latitude 281$\frac{21}{100}$ *ferè*,	2.45011

Whereby it appears, that the Distance of the Parallels of these two places is 281$\frac{21}{100}$ Poles; or that the place whereto I measure, is more Southerly than the place from whence I measured, by 281$\frac{21}{100}$ Poles. Now for the Distance of their Meridians, say,

As

As *Radius* is in Proportion
to the Distance measured, 300 Poles; 2.47712
So is the Sine of the Rumb S E 20 *deg.* 9.53405
to their Distance in Longitude 102 $\frac{6}{10}$. 2.01117

Ch.	*Poles.*
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92

And thus I find the place whereto I measured, is more Easterly than the place from which I measured, by 102 $\frac{6}{10}$ Poles, and somewhat more. And in like sort may be found all the other numbers expressed in this Table; but having thus found for every degr. to 45 degr. two numbers, the rest may be deduced from them, as in this Example: 300 Poles at three Poles to the Chain, is an 100 Chains, or ten Changes; finding that in ten Changes upon this degr. the difference Southerly is 281 $\frac{2}{10}$ Poles, it must for five Changes, which is just half so much be almost 141; and for one Change, which is a tenth part, 28 $\frac{2}{10}$ *ferè*, and so for two Changes twice so much, that is 56 $\frac{1}{10}$, for three Changes thrice so much, that is, the sum of the two former, namely, 84 $\frac{6}{10}$, and so by Addition only you may find the rest, as in this Table, which I shall need to prosecute no further. And thus you may make it to the hundredth part or thousand parts of a Pole; but this for ordinary occasions, for which it was first intended, may suffice. And according to this Example, it will be easie to frame the like Table for a Chain of any other size, or for any other Measure which you use.

It may be objected, That howsoever this Rule holds true in Plain Triangles, yet the Triangles here used are neither Plain nor Spherical; for a Plain Triangle is made of three right Lines, a Spherical of three Arches of great Circles: But in this the three sides are of several kinds; namely, one side is an Arch of the Meridian, and so of a great Circle; another an Arch of a Parallel, and so of a lesser Circle; the third side or *Hypothenusal* being the Rumb, is no Arch of a Circle, but a Segment of an *Helispherical* Line.

But I answer, That notwithstanding this may be speculatively conceived, and so demonstrated to be no Plain Triangle; yet in

	41 d.	49 d.	42 d.	48 d.	43 d	47 d.	44 d.	46 d.	45 d.	45 d.
1	226	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	905	788	892	803	878	819	864	833	849	849
5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1584	1371	1560	1406	1535	1433	1511	1458	1485	1485
8	1810	1575	1783	1607	1754	1638	1727	1666	1697	1697
9	2836	1772	2006	1807	1974	1842	1943	1874	1910	1910
10	2264	1968	2229	2007	2194	2046	2158	2084	2122	2122
1	8	7	7	7	7	7	7	7	7	7
2	16	14	14	14	14	14	14	14	14	14

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And so is the Sine of the Rumb, to the distance of the Meridians of those two places. As, admit I measure South-Easterly 20 *deg.* 31 Poles, here then the Rumb upon which I measure, making with the Meridian an Angle of 20 *deg.* I say,

As *Radius* is in proportion	
to the Distance measured, 300 Poles;	2.47712
So is the Sine Complement the Rumb, SE 20 *deg.*	9.97299
to the Difference of Latitude 281$\frac{21}{100}$ *ferè*,	2.45011

Whereby it appears, that the Distance of the Parallels of these two places is 281$\frac{21}{100}$ Poles; or that the place whereto I measure, is more Southerly than the place from whence I measured, by 281$\frac{21}{100}$ Poles. Now for the Distance of their Meridians, say,

As

As *Radius* is in Proportion to the Distance measured, 300 Poles;	2.47712
So is the Sine of the Rumb S E 20 *deg.*	9.53405
to their Distance in Longitude 102 $\frac{684}{1000}$.	2.01117

Ch.	*Poles.*
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92

And thus I find the place whereto I measured, is more Easterly than the place from which I measured, by 102 $\frac{6}{10}$ Poles, and somewhat more. And in like sort may be found all the other numbers expressed in this Table; but having thus found for every degr. to 45 degr. two numbers, the rest may be deduced from them, as in this Example: 300 Poles at three Poles to the Chain, is an 100 Chains, or ten Changes; finding that in ten Changes upon this degr. the difference Southerly is 281 $\frac{9}{10}$ Poles, it must for five Changes, which is just half so much be almost 141; and for one Change, which is a tenth part, 28 $\frac{2}{10}$ *ferè*, and so for two Changes twice so much, that is 56 $\frac{1}{10}$, for three Changes thrice so much, that is, the sum of the two former, namely, 84 $\frac{6}{10}$, and so by Addition only you may find the rest, as in this Table, which I shall need to prosecute no further. And thus you may make it to the hundredth part or thousand parts of a Pole; but this for ordinary occasions, for which it was first intended, may suffice. And according to this Example, it will be easie to frame the like Table for a Chain of any other size, or for any other Measure which you use.

It may be objected, That howsoever this Rule holds true in Plain Triangles, yet the Triangles here used are neither Plain nor Spherical; for a Plain Triangle is made of three right Lines, a Spherical of three Arches of great Circles: But in this the three sides are of several kinds; namely, one side is an Arch of the Meridian, and so of a great Circle; another an Arch of a Parallel, and so of a lesser Circle; the third side or *Hypothenusal* being the Rumb, is no Arch of a Circle, but a Segment of an *Helispherical* Line.

But I answer, That notwithstanding this may be speculatively conceived, and so demonstrated to be no Plain Triangle; yet in

ſo ſmall Diſtances as theſe which here we uſe, there can be no ſenſible nor ſcarce any numerable difference. Yea, the Diſtance between two Parallels by the Rumb and Diſtance given (being the thing here chiefly aimed at) is very exactly found by this Rule, as before we have ſhewed, and as is more fully demonſtrated by Mr. *Wright*, in the twelfth Chapter of his Book, *Of the Correction of Errors in Navigation:* Whence we may conclude, that the parts of the Meridian collected by this Table according to the Rumbs and Diſtances, as we have before ſhewed, do give the true meaſure of the Segment of that Meridian intercepted between the Parallels of the two places propoſed.

CHAP. IV.

Of the difference of Longitude, Poſition, and Diſtance of York *and* London: *And how the Maps of* England *may by this Experiment be reformed, eſpecially in the Latitude of Places.*

WE come next to ſpeak of the Eaſterly and Weſterly Diſtances gathered, as before is ſhewed by theſe Tables, and to find thereby the difference of Longitude; and of this we will give an Example in the foreſaid Experiment; whereby we find that the diſtance in Longitude, or the Eaſt and Weſt Diſtance between *York* and *London*, is near 14000 Poles, *London* being ſo much more Eaſterly than *York*. And before we have found that in a deg. of the Meridian, and conſequently in a deg. of the Equinoctial, there is near 3709 $\frac{1}{10}$ Chains, at 6 Poles to the Chain, and this 14000 Poles converted into ſuch Chains, is 2333 $\frac{1}{3}$.

Which 2333 $\frac{1}{3}$ Chains, for finding the difference of Longitude) are not to be reckoned in the Parallel of *York*, that being too much Northerly; neither in the Parallel of *London*, being too much Southerly, but in a middle Parallel between both; namely

namely, about the Latitude of 52 deg. 45 min. Now to find what difference of Longitude is anſwerable to this 2333 $\frac{1}{3}$ Chains in the Parallel of 52 *deg.* 45 min. ſay,

As *Radius* is in proportion	
to Sine Complement the Latit. *ſc.* 52 deg. 45 min.	9.78197
So is the meaſure of a deg. in the Equinoctial 3709 $\frac{1}{19}$.	3.56927
to the meaſure of a deg. in that Parallel 2245 $\frac{1}{10}$.	3.35124

And thus we find that in the Parallel, whoſe Latitude is 52 deg. 45 min. there are 2245 $\frac{1}{19}$ Chains anſwering to a deg. whereby it appears that the difference of Longitude between *York* and *London*, is more than one deg. and to find how much more, ſay again by the Rule of Proportion;

As the meaſure of a deg. 2245 $\frac{1}{10}$ *Co. Ar.*	6.64876
is to a deg. in ſeconds, 3600	3.55630
So is the meaſure given, 2333 $\frac{1}{3}$	3.36797
to the number of ſeconds, 3741	3.57303

Which reduced, is 1 deg. 2 min. 21 ſec. and thus we find that *London* doth differ in Longitude from *York* 1 deg. 2 min. 21 ſec. being ſo much more Eaſterly.

Thus having the difference of Latitude, as alſo the difference of Longitude between theſe two places, we may (according to the Second Problem of Sailing by *Mercator*'s Chart) find the Rumb from *London* to *York* to be 14 deg. 20. min. from the North to the Weſtwards; that is, North and by Weſt 3 deg. 5 min. Weſterly, and the diſtance in that Rumb 9442 Chains. But their diſtance in the High-way, by reaſon of the crookedneſs and unevenneſs of it, was more by about an eighth part.

And the like might be done for other immediate Places between theſe, but affecting brevity, we paſs over, as not much pertinent to our preſent purpoſe; only expreſſing the Latitudes of ſome of the principal of them, as followeth.

	Latitudes.			
As the Latitude of *York*, we find to be	53	deg.	58	min.
Doncaſter,	53	deg.	32	min.
Newark upon *Trent*,	53	deg.	5	min.
Grantham,	52	deg.	54	min.
Stomford,	52	deg.	38	min.
Huntington,	52	deg.	19	min.
Royſton,	52	deg.	3	min.
Ware,	51	deg.	48	min.
London,	51	deg.	30	min.

We further noted in this Experiment, that howſoever the number of Miles between *Ware* and *London*, are almoſt the ſame by eſtimation that they are by meaſure; yet all the way beſides from *York* to *Ware*, a meaſured Mile conſiſting of 320 Poles, is but three quarters of a Mile, as the Miles lie by eſtimation or common account; ſo that every where (for the moſt part) three Miles by eſtimation make four meaſured Miles; and a min. or the 60*th* part of a deg. is almoſt the middle between them both. So that look how much a meaſured Mile is leſs than a min. ſo much, or ſomewhat more is a Mile by eſtimation greater than a min. for as there is contained in a degr. of meaſured Miles 69 $\frac{1}{2}$ and ſomewhat more, as we have before ſhewed; ſo of our common eſtimated Miles, there are contained about 51 $\frac{3}{5}$ in a degree.

Upon theſe Grounds the whole Maps of this Kingdom might be much rectified, eſpecially in the Latitude of Places; for though we cannot hence determine certainly the Latitudes of any other places beſides thoſe which were in the way, or at leaſt in ſight as we came up (the principal of which we have before noted.) Yet we may nearly conjecture the Latitudes of moſt parts of *England*, by their Diſtances and Poſitions from theſe; but theſe things being beſides our ſcope and purpoſe in this place, we ſhall only compare the Latitude of ſome principal places, probably gathered from this Experiment, with the Latitudes of the ſame places, as they are ſet down by Mr. *Speed* in his *Geographical* Deſcriptions of *England*; that ſuch as pleaſe to examine both in any particulars, may know to which they may more ſafely lean.

Canterbury

	Latitud. by this Exper.		Latitud. by Mr. Sp. Map.	
	D.	M.	D.	M.
Canterbury	51	17	51	29
Chicheſter	50	48	50	51
Guildford	51	12	51	22
Wincheſter	51	03	51	11
Dorcheſter	50	40	50	44
Exceſter	50	43	50	48
Wells	51	12	51	22
Saliſbury	51	04	51	22
Redding	51	28	51	42
London	51	30	51	45
Colcheſter	51	58	52	16
Ipſwich	52	08	52	30
Norwich	52	42	53	10
Cambridge	52	12	52	32
Hertford	51	49	52	06
Bidford	52	08	52	30
Buckingham	52	00	52	20
Royſton	52	04	52	24
Oxford	51	46	52	02
Gloceſter	51	53	52	12
Hereford	52	07	52	27
Worceſter	52	14	52	36
Warwick	52	20	52	45

	Latitude by this Exper.		Latitude by Mr. Sp. Map.	
	D.	M.	D.	M.
Northampton	52	14	52	36
Huntington	52	19	52	44
Stamford	52	38	53	04
Leiceſter	52	40	53	05
Lincoln	53	14	53	50
Newark upon *Trent.*	53	05	53	38
Nottingham	53	00	53	32
Derby	52	58	53	30
Stafford	52	52	53	22
Shrewsbury	52	47	53	16
Cheſter	53	16	53	52
Lancaſter	54	10	54	57
York	53	58	54	44
Richmond in *Yorkſhire*	54	28	55	18
Kingſton upon *Hull*	53	48	54	29
Doncaſter	53	32	54	12
Durham	54	50	55	45
Carlile	55	00	55	56
Newcaſtle	55	03	56	01
Barwick	55	54	57	03

The Latitudes of theſe places in the firſt Column expreſſed, are ſuch as are probably gathered from this Experiment. But in the ſecond Column there is ſet down the Latitudes of the ſame places, as they are expreſſed by Mr. *John Speed* in his Map of *England*, ſet forth in his Book, entituled, *The Theatre of the Empire*

Empire of Great Britain; and leſt there ſhould be any miſtake in his Map, I have conferred theſe Latitudes thence gathered, with the Latitudes of the ſame places, ſet down by him in words at large, in his Deſcriptions of each ſeveral County, and find them nearly to agree, except in the Latitude of *Berwick*, which in his Map he makes to be 57 degr. 3 min. But in his Hiſtorical Deſcriptions of *Northumberland*, he relates it to be 55 degr. 48 min. which laſt is much nearer the truth, but ſeems not to be his meaning; becauſe then he ſhould make it more Southerly than *Newcaſtle*, yea, more Southerly than he doth *Carlile*, which by his Map, and alſo by his words in his Relation of *Cumberland*, is in the Latitude of 55 deg. 56 min. whereas *Berwick* is above 50 Miles more Northerly.

By theſe you may nearly conjecture the Latitudes of other parts of *England*, lying in or near the ſame Parallel with any of them: And hence it alſo appears, that the difference of Latitude between *Berwick*, and the South Coaſt of *England* near *Chriſt-Church*, is little more than 5 degr. not 6 degr. and more, as ſome of our Maps make it. But theſe things we muſt leave, that we may proceed to that which is principally intended, only we will firſt touch a little upon the uſe of the fore-going Table, in plotting and ſurveying of Land.

CHAP. V.

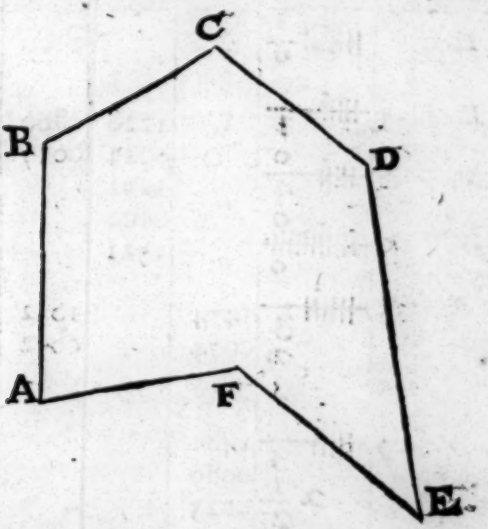
To delineate the Plot of any Foreſt, Park, Common, or other pieces of Ground; as alſo of Rivers, Harbours, &c. *ſpeedily and moſt exactly,*

MY intent is not here to proſecute at large the Plotting of the Grounds, being a thing handled by others, treating of *Surveying:* But conſidering that the ways by them directed, and by others practiſed, in delineating or laying down the Diſtances and Angles obſerved by the *Circumferentor*, *Theodolite*, *Peractor*, or other graduated Inſtrument, is by a *Protractor*, and that the Table before-going, or that which followeth

followeth towards the end of this Treatiſe, ſerveth for that and the like purpoſes, almoſt as ſpeedily, and far more exactly; I ſhall crave leave to digreſs a little to ſhew this Uſe of it as briefly as I may. Therefore paſſing over the method to be uſed in ſetting down the Names of the Grounds, the Tenants, Borderers, and other remarkable things, and leaving every man in theſe to the ways whereunto he is accuſtomed. You may (as ſometimes I do) make a Book in a long *Octavo*, and upon the left ſide thereof ſet down ſuch things as theſe before mentioned, reſerving every right ſide, and dividing them by Ruled Lines into ſix Columns; as hereafter following appeareth.

And having taken and ſet down your Notes in the Field on the left ſides or Pages of your Book, you may in the evening or next morning before you go out, or when elſe your occaſions will permit, ſet down the firſt Columns on the right ſide, how many degr. the Lines upon which you have Traverſed, are diſtant from the North or South part of the Meridian towards the Eaſt or Weſt; and in the ſecond Columns the quantity of the ſame Lines, in Changes, Chains, and ſingle Poles, and parts of Poles.

As in this Figure; ſuppoſe the Line from *A* to *B* to be di-



rectly

rectly East, 7 Changes, that is, 7 times 30 Poles, or 210 Poles. From *B* to *C* to the Eastwards of the South 35 deg. 5 Changes, and 1 Chain, from *C* to *D*, to the Westwards of the South 32 deg. 5 Changes, and 4 Chains, from *D* to *E* to the Westwards of the South 80 deg. 10 Changes, from *E* to *F*, to the Eastwards of the North 35 deg. 6 Changes, 3 Chains, and two thirds of a Pole. And lastly, from *F* to *A*, the place where I first began, to the Westwards of the North 9 deg. 5 Changes, 3 Chains, $2\frac{1}{2}$ Poles. All these I express in the first and second Columns on the right side, as hereafter following appeareth.

Which done, I take the Table, and find there the Northing and Southing, Easting or Westing answering to these degr. and Distances, and set them down accordingly. As for the first, being East 7 Changes, I set down in the East Column 210 Poles with a Cypher behind it. For the second, being South-East 35 degr. I find in the Table for 5 Changes 1228, to be set in the South Column, and 860 for the East Column; also upon the same degr. for 1 Chain 25 for the South Column, and 17 for the East Column; and so I proceed with all the rest, until I have finished.

Deg.		Distance.	North.	South.	East.	West.
East.		0			2100	
S. E.	35	7		1228	0860	
		0		0024	0017	
S. W.	32	4		1272		0795
		0		0102		0064
S. W.	80	10		0521		2954
N. E.	35	3	1474		1032	
		$\frac{2}{3}$	0074		0052	
			0005		0004	
N. W.	09	3	1481			0234
			0089			0014
		$2\frac{1}{2}$	0025			0004
			3148	3148	4065	4065

And being thus returned to my first Station, I sum up severally these four Columns of North, South, East and West; and finding that the sum of the North Column is equal to that of the South, and the sum of the East is equal to that of the West, I conclude the whole Work to be truly performed; whereas if there had been any difference, it had shewed an Errour; and if that difference had been great, it had been necessary to examin the Work again, and so to correct it.

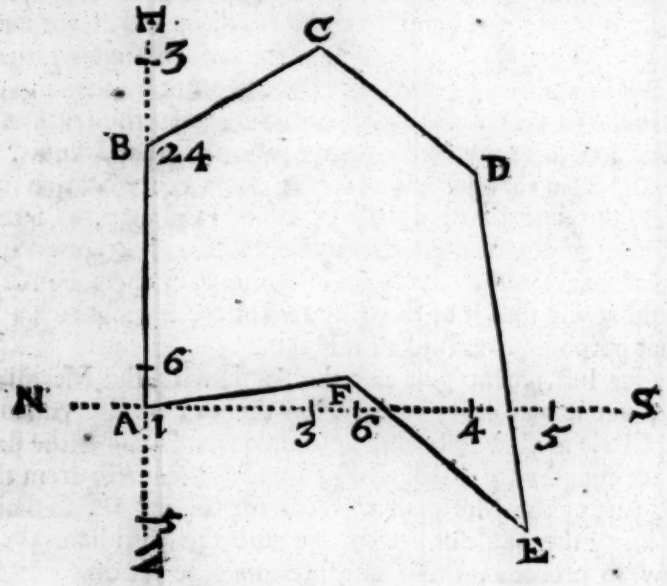
It is usual to add together all the Angles, and also to multiply two right Angles, or 180 degr. by the number of Angles lacking two; and if the sum of the Angles added together, be equal to this Product, the Work is thought to be true: As here, if we add the Inclinations and Reclinations of these Lines in this Figure, the sum is 720 degr. or eight right Angles; and if we multiply two right Angles by 4, (because here are six Angles) the Product is also eight right Angles. But the other by the sums of the Columns, is a most absolute way for examining the truth of your Work, and to be preferred before any other that I know.

It may seem very laborious to set down every Station in this manner, but one that is a little exercised in it may, as I take it, (for I never observed the time exactly) set down 40 or 50 Stations in this manner, within the space of an hour, or thereabouts. But I should advise that it be done by two men, having each a Table for that purpose, to avoid all mistakes.

If your Instrument give not the Angle with the Meridian expresly, yet it may easily be gathered thence; or else you may divide a Circle as your Instrument is divided, and number the degr. as they are numbred; which done, number them also from the *N.* and *S.* part of the Meridian towards the *E.* and *W.* so shall you easily know the Angle of any degree with the Meridian.

Now to proceed, these measures may be set down in a Plot several ways. As first, considering which way the Ground lies, I take a Point for my first Station; so as the whole may fall conveniently within the Plot, which let be the Point *A*, by which Point I draw a Meridian and Parallel, namely two right Lines intersecting one another at right Angles: whereof let *N. S.* be the Meridian running North and South, and *E. W.* the Parallel running East and West; this done, I look to the North and South Columns,

and there first in the South Column, and against the third Station, I find 1253, that is, 125.$\frac{3}{10}$ Poles, this I set in the Meridian from *A* to the Southwards, and mark the Point with the Figure 3; then in the South Column against the fourth Station, I find 1374, which I set in the Meridian from 3 to 4; also against the first Station I find 521, which I set in the Meridian from 4 to 5. Then against the sixth Station, I find in the North Column 1553, which I set in the Meridian from 5 to 6; also against the seventh Station, which is the same with the first, I find 1595, which I set in the Meridian from 6, and it falls upon *A*, which is the first Station. And thus have I done with the South and North Columns.



In like sort I expres the Measures in the East and West Columns in the Parallel *E W*. As finding first in the East Column 2100, I set it down from *A* to the Eastwards, and it extends to *B*, where I set 2, signifying my second Station; I find next in the East Column 877, which I set in that Parallel from 2 to 3, next in the West Column 859, which I set in that Parallel from

3 to

3 to 4; and ſo I proceed with the reſt. And having thus ſet down the Meaſures in the Meridian and Parallel, we have alſo as it falls out in this Example, two Stations expreſs'd, namely *A* and *B*; now for the third, I take in the Parallel with my Compaſſes the diſtance *A* 3, and ſetting one foot in the Meridian at 3, I ſtrike an Arch near *C*; alſo taking in the Meridian the diſtance *A* 3, and fixing one foot in the Parallel at 3, I croſs the foreſaid Arch near *C*, the interſection of theſe two Arches is the Point *C*, repreſenting the third Station.

In like ſort, I proceed to find the Point *D E F* for the fourth, fifth and ſixth Station; then drawing Lines, namely, from the firſt Station *A* to the ſecond *B*, and from the ſecond to the third *C*, &c. We ſhall deſcribe the Figure required, *A B C D E F*.

Otherwiſe, whereas here you Add and Subtract the ſeveral Diſtances of South and North, as alſo of Eaſt and Weſt by your Compaſſes, you may with a little more pains Add and Subtract them by the Pen, which is the better way.

As having ſet down in the Meridian the Southerly diſtance of the third Station 1253, I add thereto 1374, which is againſt the fourth Station, the ſum is 2627, the Southerly diſtance of the fourth Station, which I ſet in the Meridian from *A* to 4. Again, to this I add 521, ſo have I 3148, the Southerly diſtance of the fifth Station *A* 5, from which ſubtracting 1553, the Northerly diſtance ſet againſt the ſixth Station, there remains 1595, which is the Southerly diſtance of the ſixth Station, to be ſet in the Meridian from *A* to 6. Laſtly, from this, abating the Northerly diſtance of the firſt Station from the ſixth, which I find there alſo to be 1595, there remains 0. Shewing that I am returned to the ſame Parallel, or Eaſt and Weſt Line, in which at firſt I began. And in like ſort, you may proceed with the Eaſt and Weſt Columns, and then by the interſection of two Arches, find every Station as before.

Other ways might be preſcribed, which will not be hard to find of your ſelf. And as we may thus lay down any irregular right-lined Figure far more exactly than by the *Protractor*: So when it is laid down after this manner, we may caſt up the *Area* or ſuperficial quantity of it very exquiſitely: Yea, if there ſhould be a Plot drawn (according to the Angles and Diſtances herein

given) after the uſual manner, by a Scale ſo large, that the Plot ſhould be an hundred times ſo great as this; yet could not the Content thereof be caſt up ſo exactly and certainly as it may be here.

But I muſt not inſiſt upon theſe things, they may of themſelves be conceived, and my intent is only to teach them, that I be not prevented of time, and by other occaſions from handling thoſe things which I have here more eſpecially intended.

But as I have ſaid, this courſe is chiefly to be uſed in Plotting large Grounds, and there indeed are graduated Inſtruments, eſpecially to be uſed for other ſmaller Grounds; there is none more fit than the *Plain Table*.

CHAP. VI.

Of the Compaſs of the Earth, and the quantity of a Degree, according to the moſt approved Experiments Ancient and Modern.

ALthough the Compaſs of the Earth hath been in ſome ſort obſerved by divers of the Ancients: yet for ſome of them we cannot certainly gather what meaſures they uſed; others uſed no meaſure at all, but aſſumed the Diſtance of places to be ſuch as it was eſteemed by Travellers to be, and likewiſe the Latitude; therefore it will be needleſs to inſiſt upon the examination of their Obſervations: others of them which were taken by meaſure, and which we may upon any good ground reduce to our meaſures, are theſe which follow.

Willebrordus Snellius in his Book entituled *Eratoſthenes Batavus*, cites *Abel Fedas*, a moſt diligent *Arabian* Geographer, that lived about the year of Chriſt 1322, who records, that about the year of Chriſt 827, certain men skilful in the *Mathematicks*, did by the commandment of their Prince *Almanon*, meaſure in the Fields of *Meſopotamia* (as he gathers) under one and the

the ſame Meridian, from the North towards the South, the quantity of a Degree, and found it to be 56 Miles, or ſomewhat more. The quantity of their Mile, according to *Alphraganus*, was 4000 Cubits, or 6000 Feet, whence the quantity of a Degree ſhould be 336000 Feet; but of the length of their Feet we are ſomething uncertain; only they define it to be ſo long as the extent of 96 Barley-corns laid ſide by ſide; whereas the *Rynland*-Foot, according to tryal by him made, is but the extent of 90 Corns laid in like manner; ſo that if there be no inequality in the Grains, then 90 *Arabian*-Feet are equal to 96 *Rhynland*-Feet. But 96 *Rhynland*-Feet are found to be about 91 $\frac{1}{6}$ *Engliſh*-Feet; therefore alſo by the Rule of Proportion, 336000 *Arabian*-Feet do make of our *Engliſh*-Feet 370222. So that according to this Experiment of the *Arabians*, a degr. ſhould contain 370222 of our *Engliſh*-Feet. And before we have found by the Obſervations taken at *London* and *York*, and by the diſtance of the Parallels meaſured, that a Degree contains of our *Engliſh*-Feet 367200. The difference is only 3022 Feet, that is, about the $\frac{1}{120}$ part of a degr. or half min.

He cites next *Alhazen* the *Arabian*, who in his Book *de Crepuſculis*, declares the Compaſs of the Earth to be 24000000 Paces; ſo that proportionally there muſt be in one degr. 66675 $\frac{2}{3}$ Paces, that is 333333 *Arabian*-Feet. And ſeeing the 90 *Arabian*-Feet make of our *Engliſh*-Feet 99 $\frac{1}{4}$, therefore by the Rule of Proportion 333333 *Arabian*-Feet, make of our *Engliſh*-Feet 367283. So that according to *Alhazen*, there ſhould be in a degr. 367283 of our *Engliſh*-Feet, differing from the Experiment which I made only 83 Feet in a degr.

I have not ſtrained theſe numbers to bring them to this nearneſs, they are the ſame in effect which are ſet down by *Snellius* in his *Eratoſthenes Batavus*, who with great induſtry and judgement hath compared the meaſures of the Ancients, and the meaſures uſed by ſeveral Nations in theſe times, with the *Rhynland*-Foot. Much leſs have I ſtrained my own numbers to draw them up to theſe: But on the contrary, I confeſs upon the ſight of his Book, obſerving the great pains and induſtry which he profeſſeth himſelf to have beſtowed, and which I doubt not but he did employ in making his Experiment, and how he had found

found the measure of a degr. to be much less than mine, as we shall after shew; I began to doubt that I had not made sufficient allowance for the unevenness of the ways, and for some small bendings, sometimes to the right hand, sometimes to the left, the Observation whereof I wittingly neglected, to spare time and expence. For I did often observe a Mile or two before me, some Mark in the High-way, noting the degr. and measuring to it in the way, neglecting to observe the intermediate swerving of the way, sometimes three or four degr. towards the right hand, sometimes as much to the left; but making such allowance for that, and for the unevenness as I judged sufficient. And some men may think, that the exact Observation of these lesser things thus neglected, and regulated only by judgment or conjecture, might deceive me much: But they may consider, that if there be two places a Mile distant, that is, in a right Line 320 Poles, if you measure from one of these places towards the other, not in that right Line, but always swerving from it by an Angle of four degr. sometimes to the right hand, sometimes to the left, till you come to that other place; I say, that notwithstanding all these swervings (if there be nothing else to augment the measure) it will not amount to 321. Now considering that I had all the way, as occasion required, made such allowance as seemed convenient, and so found 367200 Feet in a degr. before I compared it with the measures taken by any other; I resolved not to diminish nor to augment the numbers thus arising by my Observations, Measures, and Allowances, in respect of the Opinions, Observations, or Measures of any other man, until there be made some Experiment more evident and exact than any yet extant. And I am something the more confirmed by the near agreement of these two testimonies before recited, both exceeding me a little in the measure of a degr. But we cannot confidently rest upon them, because of that inequality which may be of Corns or Grains; for theirs may haply be something greater or less than ours.

Both these measures of a degr. do much exceed the quantity of a degr. found by *Snellius*, but when he compares them with his own another way, namely, placing the Barley-Corns so that they may not lie flat, but be set up edgewise, and so by 96 Corns to make a Foot, and by such Feet to measure a Degree; then he finds

finds that the quantity of a Degree, according to the *Arabians*, is much leſs than by his Experiment it ſhould be: but if ſome be laid flat, and others ſet up edgewiſe, the *Arabian* meaſure of a Degree will agree with his. And ſo he propoſeth this doubt, Whether the 96 Grains, whereof the *Arabian* Foot doth conſiſt, muſt lie flat or be ſet up edgewiſe, or ſome of them to lie flat, and others to be ſet up edgewiſe. But it is moſt probable that they muſt lie flat, that being the poſition which they are apt unto by nature; they cannot be ſet edgewiſe without much trouble, eſpecially ſo many together as make the length of a Foot; and ſo the *Arabian* meaſure of a Degree doth near agree with this of mine.

We come next to hear the determination of *Ptolomy* of *Alexandria*, whoſe authority and credit in the ſolution of this Queſtion, is not inferiour to any of the Ancients. He affirms the Compaſs of the Earth to be 180000 *Stadiums*, and the quantity of a Degree 500 *Stadiums*; the ſame (as *Strabo* ſaith in his ſecond Book of *Geography*) was before affirmed by *Poſidonius*. Alſo *Martinus Tyrius* (before *Ptolomy*) had determined the quantity of a degr. to be 500 *Stadiums*. *Ptolomy* confirms it, not ſimply from their relations, but as it ſeems from his own experience, and that by ſome meaſures diligently taken; for in the eleventh Chapter of the firſt Book of his *Geography* he hath theſe words; *Sed in hoc quoque rectè ſentit, partem unam, qualis eſt circulus maximus trecentorum ſexaginta, quingenta in terra conſtituere Stadia, id enim confeſſis dimenſionibus conſonum exiſtit.* Alſo *lib. 7. cap. 5. Ita ut pars una, ſeu gradus unus quingenta contineat Stadia, quemadmodum ex diligentibus deprehenſum eſt dimenſionibus.* Now a *Stadium* not only among the *Greeks*, but as appears by *Herodotus* amongſt all other Nations of *Aſia* and in *Egypt*, did conſiſt of 600 Foot; therefore a Degree according to *Ptolomy*, muſt contain 300000 Feet. But the *Egyptian* or *Alexandrian* Foot was much greater than our Foot; for as we have before ſaid, the ancient *Roman* Foot is greater than ours, and the *Egyptian* Foot was much greater than the *Roman*: for it is often teſtified by *Hero Mechanicus*, that 5 *Alexandrian* Feet make 6 *Roman* Feet. And Mr. *Snellius* hath very ingeniouſly gathered both from *Philandes* and otherwiſe, that the *Rhynland* Foot is equal to the ancient

Romans

Roman-Foot; therefore alſo 5 *Alexandrian*-Feet are equal to 6 *Rhynland*-Feet: So that by the Rule of Proportion, 300000 *Alexandrian*-Feet, will make of *Rhynland*-Feet 360000. But by the ſize of our *Engliſh*-Foot, which was ſent him from the Iron Standard in *Guild-Hall*, he finds it to contain but 968 ſuch parts as the *Rhynland* contains 1000: So that 968 *Rhynland*-Feet are equal to 1000 *Engliſh*-Feet, or 121 *Rhynland*-Feet are equal to 125 *Engliſh*-Feet. Therefore alſo by the Rule of Proportion, 360000 *Rhynland*-Feet are equal to 371900 of our *Engliſh*-Feet. Therefore according to *Ptolomy*, there are contained in a Degree 371900 of our *Engliſh*-Feet. But by our fore-mentioned Experiment made between *York* and *London*, we find only 367200 Feet in a degree, being leſs than *Ptolomy*'s by 4700 Feet, that is, by $\frac{1}{80}$ part of a deg. or $\frac{1}{4}$ of a min. and little more.

Fernelius, a Modern Author and Learned Phyſician, meaſuring the way by Revolutions of a Wheel, and the Latitudes by Obſervation, finds in a degr. 68 *Italian* Miles, and 96 Paces, the Pace which he uſed being more than 5 of our *Engliſh*-Feet. But becauſe he handled not the Problem exactly, and is ſuſpected by *Snellius* (though I think without cauſe) to have grounded his Concluſion rather upon the Experiment of the *Arabians* before ſet down (wherewith it doth nearly agree) than upon his own, we will inſiſt no longer upon it.

We come in the laſt place to the Experiment of *Willebrordus Snellius*, a *Hollander*, made in the *Netherlands* about 20 years paſt. We ſhall not need to recite the particulars of it, being extant at large in his Book before mentioned: but in concluſion, he finds in a degr. 342000 *Rhynland*-Feet. Now a *Rhynland* Foot (as he hath there ſhewed, comparing both together) is greater than ours, and that in ſuch Proportion, as 1000 is to 968; (and ſo much, or little more, it appears to be by that Model of the *Rhynland*-Foot printed in his Book) therefore 968 *Rhynland*-Feet muſt make 1000 of ours; and hence by the Rule of Proportion, 342000 *Rhynland*-Feet, will make of our *Engliſh*-Feet 353306. So that there ſhould be in a degr. only 353306 Feet, which is leſs than we have before found in a degr. by 13894 Feet, that is, by the $\frac{1}{80}$ part of a degr. or $2\frac{1}{4}$ min. and ſomething more. He was a man doubtleſs of ſingular induſtry and knowledge, and of much

much exerciſe in the *Mathematicks*, and it may be was well experienced in this particular, touching the *Geometrical* Menſuration of Diſtances, and he hath beſtowed much pains and diligence in this Experiment, as by his Book appeareth. But if he had by a Chain meaſured the Diſtance of his two utmoſt Stations (if the ground would permit, which I ſuppoſe it would not) or at leaſtwiſe if his meaſured Stations had been further diſtant; I conceive he would have found a greater Diſtance in his two utmoſt places of Obſervation. But if a man, intending to find the diſtance of two places, meaſure only the $\frac{1}{100}$ part of that Diſtance, and by that meaſured Line and the Angles, think to find their true Diſtance; whether he do it immediately from the two meaſured Stations, or immediately by help of others obſerved from them, he may eaſily fall into ſome notable Error. For though the Problem be exactly true in Geometrical Demonſtrations, how ſmall ſoever the meaſure be, yet it is not ſo in ſenſible and experimental Practices, by reaſon of the weakneſs even of the beſt Eye, and the imperfection of the Inſtruments themſelves, and in their uſe. And beſides that there were many Stations obliquely ſituate; a man cannot always hit the juſt middle of that Turret, Steeple, or other mark which he obſerves; neither when he comes to make his Station there, can he always place his Inſtrument juſt at the concourſe of his former viſual Lines, by reaſon of other impediments. Beſides the force of the wind in ſuch eminent places; and moreover, that amongſt ſo many Steeples as there are in ſome Towns, there, a man may at ſome time miſtake one for another. And if there ſhould happen no notable Error, by reaſon of any or of all theſe Caſualties: yet may two minutes, in the difference of the Latitudes of two places be eaſily miſtaken, eſpecially being derived from the Latitudes of thoſe places which are very rarely ſet down true to a minute.

If it be objected, that I might as well be ſo much miſtaken in the differences of the Latitude of *York* and *London*.

I anſwer, it is not ſo likely, becauſe I had the opportunity of obſerving the Summer Solſtitial Altitude of the Sun in both places, wherein I had no neceſſary uſe of the Suns Parallax nor Refraction, nor of the Table of the Suns Declination, any of which may cauſe more than a min. error, in finding the Latitude of either place.

Besides, if mine Errour in those Observations should be full as much, yet would it not in the Conclusion be half so much, because the difference in Latitude of the two places of my Observation is more than twice so much as that of his.

About the year 1672 Monsieur *Picart* published an Account in *French*, concerning the measure of the Earth, a breviate whereof may be seen in the *Philosophical Transactions*, *Num.* 112. wherein he concludes one Degree to contain 365184 *English*-Feet, nearly agreeing to Mr. *Norwood*'s Experiment.

But let this suffice, leaving every man to embrace that which he shall best approve. Both our Experiments do sufficiently convince that common Errour of counting only 300000 *English*-Feet to a degr. besides the consent of other Observations before recited, ancient and modern.

Mr. *Snellius* hath further in that Book of his, entituled *Eratosthenes Batavus*, with much diligence compared some ancient measure, as also the measures of sundry foreign Countries with the *Rhyniand*-Foot; and amongst the rest, our *English*-Foot, according to a size thereof to him sent from the Standard in *Guild-Hall*, (from whence also I had about 20 years past, the size of that Foot, which I have used in this measure,) we shall not need to repeat them all, because his Book is extant: Some of them are these following, which we here compare to our *English*-Foot, as he hath there done to the *Rhynland*, that so any of them may be the more easily reduced into our Feet. Therefore dividing the *English*-Foot into a thousand equal parts, we shew how many of those parts are contained in other Ancient and Foreign Feet.

Ancient Feet compared with our English-*Foot.*

Of such parts as the *English*-Foot contains		1000
The	Ancient *Roman*-Foot contains	1033
	Ancient *Greek*-Foot contains	1076
	Babylonian-Foot contains	1211
	Alexandrian-Foot contains	1240
	Antiochean-Foot contains	1405
	Arabian-Foot contains	1102

Foreign

Foreign Feet compared with our English-*Feet.*

Of ſuch parts as the *Engliſh*-Foot contains		1000
The	*Rhyneland*-Foot contains	1033
	Dort-Foot contains	1085
	Middleburgh-Foot contains	992
	Amſterdam-Foot contains	934
	Antwerp-Foot contains	932
	Levain-Foot contains	939
	Hafnian-Foot in *Denmark*, contains	965
	Paris-Foot, called the King's-Foot, contains	1090
	Venice-Foot contains	1157
	Toledo-Foot contains	896
	Noremberg-Foot contains	1006
	Straſburg-Foot contains	920

CHAP. VII.

Of dividing the Log-line, *and reckoning the Ships way.*

THere be four things, upon which the Practice of *Navigation* is eſpecially grounded; namely, the knowledge of the Longitude, Latitude, Courſe, and Diſtance. Touching the Longitude, though it may be found by the other three, yet hitherto there hath not been delivered any general Rule true and practicable, whereby the Longitude of places might be immediately and ordinarily found of themſelves. The Latitude of places may immediately be found by Obſervation of the Sun and Stars, as we have formerly ſhowed in the Appendix to the *Doctrine of Triangles*. The Courſe by the Compaſs, the Variation being duly obſerved, wherein we have many good Mariners very expert, this we have alſo handled in the *Doctrine of Spherical Triangles*. The Diſtance run is found of it ſelf by the *Log-line*, whereof we are here to ſpeak.

The ground of finding the Diſtance run by the *Log-line* is meerly conjectural, being founded upon this Opinion, That 5 of our Feet make a Pace, and 1000 ſuch Paces make a Mile, and that 60 ſuch Miles make a Degree; ſo that a Degree ſhould contain 300000 of our Feet. But it appears not only by this Experiment, but even by all others that were diligently taken, and their meaſures to us known, that there is a greater number of our Feet contained in a Degree.

There be three things (as I conceive) that have cauſed this Error to be ſo commonly received and tolerated. The one, for that it doth ſomewhat counterpoiſe another contrary Error in the Practice of *Navigation*: namely, in the uſe of the *Plain Chart*; for, the Error which is there committed by making every Parallel equal to the Equinoctial, and ſo every Degree in them greater than they ſhould be, is ſomething moderated by this Error; whereby the meaſure of a Degree is eſteemed leſs than indeed it is.

For Inſtance; It is evident by the *Globe*, that the Meridians concurring in the Poles grow nearer and nearer together, as they grow towards the Poles; Inſomuch, as if two Meridians be diſtant in the Equinoctial 10 degrees, that is 600 Miles, the ſame Meridians in the Latitude of 35 degr. will be diſtant little more than 490 Miles. Now if unto every Mile we account according to the former Experiment 6120 Feet, then is the diſtance of thoſe two Meridians in that Parallel near 3000000 Feet. In like ſort the *Plain Chart*, 10 deg. of that Parallel (as of all others) is made equal to 10 deg. of the Equinoctial or Meridian; ſo that the Diſtance of theſe two Meridians will upon the *Plain Chart* be 600 Miles, but one of theſe Miles contains only 5000 Feet, ſo that the Diſtance is but 3000000 Feet, equal to the former.

And although theſe Errors in other caſes do not juſtly ballance one another, as in this Example, yet that of the *Plain Chart* is always ſomething moderated by this other, and ſo much the more by how much they are nearer to the aforeſaid Latitude. I grant that this is only ſo when the Courſe is near unto the Eaſt or Weſt Points; but withal, I ſay that this kind of reckoning is (in a manner) then only uſed: For he that runs any Courſe near the Meridian Southerly or Northerly, hath a more certain way of reckoning,

reckoning, namely his Latitude, which he finds daily by Observation of the Sun and Stars, upon which he will depend, either neglecting, or at leaſt not regarding his dead reckoning. Yea, (if it may be) never caſting the *Log* ſo much as once in ſuch a Voyage, having a more ſure ground for his reckoning. But in a Courſe that is near the Eaſt and Weſt (foraſmuch as there is no way diſcovered for finding the Longitude) he is driven of neceſſity to make uſe of his dead reckoning.

We might add moreover, that the principal Voyages of this kind, I mean of thoſe which conſiſt of Courſes much Eaſterly and Weſterly, as to and from the *Weſt-Indies*, and the Parallel of *Cape bon Eſperance* are near unto this Latitude of 35 degr. ſo that as ſome of them are more Southerly, others of them are more Northerly.

But to inſiſt no longer upon this, I ſuppoſe a ſecond cauſe to be, for that men commonly deſire to have their reckoning before their Ship (as they ſay) that they fall not with a place before they look for it: And this comes ſo to paſs, whilſt the Miles are accounted leſs in meaſure, and ſo more in number than they are indeed.

And thus, though there may ſeem to be ſome commodity in theſe Errors, eſpecially when they do nearly ballance one another; yet becauſe they ſeldom do ſo, but always leave men in uncertainties, and oftentimes in great perplexity and danger, it is much ſafer and better to reject them both, and to embrace thoſe ways which are evidently grounded upon truth, though there may be in them ſome more difficult at the firſt. Yet I confeſs, that he which reforms one and not another, may ſometimes erre ſo much the more thereby. And I doubt not, but many would reform them both, if they could certainly do ſo.

Therefore a third cauſe of admitting and retaining this Error ſeems to be; for that there hath been no way delivered from evident and certain Grounds for the rectifying of it. I doubt not but many have found Errors in their Reckonings ariſing from hence, that they account only 300000 of our Feet to a Degree; but not knowing certainly where to lay the fault, have imputed it ſometimes to ill Steerage; otherwhiles to the variation of the Needle, or to ſome miſtake in their Reckonings, or to ſome Error in their Plots, or to ſome Current, or ſuch other accident, and ſo

the

the Errour hath reſted unreformed. Wherefore although the practical performance of this Problem for finding the Circumference of the Earth, or the quantity of a Degree on the ſame, have many ſingular uſes which I cannot now touch; yet that which amongſt the reſt I chiefly aimed at, was, that we might have a more ſure and evident ground for dividing the *Log-line*, and for reckoning the Ships way or diſtance run more truly upon any Rumb or Point of the Compaſs than formerly.

And now to apply it to this purpoſe, we have noted before (*Chap.* 2.) that by the Experiment there expreſſed, we find in a Degree on the Circumference of the Earth and Sea, 367260 of our *Engliſh*-Feet. Wherefore retaining ſtill the ſame diviſion of a degr. into 60 Miles or 20 Leagues (as hath been formerly uſed) a Mile will contain 6120 Feet, or 1020 Fathoms: and ſo a League contains 18360 Feet, or 3060 Fathoms; for dividing 367200 by 60, the Quotient is 6120, *&c.* Thus then 60 Miles being a Degree, every Mile is 6120 Feet.

Now ſuppoſing the time of the running out of the *Log-line* to be meaſured by a Half-minute-glaſs, if we obſerve how many Feet or Fathom ſhe runs in half a Minute, we may thereby find her way for an hour or 4 hours, or for any other time propoſed.

As admit there runs out of the *Log-line* in half a minutes ſpace 51 Feet, or $8\frac{1}{2}$ Fathoms, and you would know what way the Ship makes every hour after the ſame rate; ſay by the Rule of Proportion,

If $0\frac{1}{2}$ Minutes give 51 Feet,
What gives 60 Minutes? Or,
If 1 Minute gives 102 Feet,
What gives 60 Minutes?

And ſo multiplying, you ſhall find 6120 Feet, which is one Mile. Or, if you would find her way for four hours, which is 240 Minutes; ſay,

As 1 Minute, is in proportion to 240 Minutes;
So are 102 Feet, to 24480 Feet, or 4 Miles.

Or, if you would have it in Fathoms; ſay,

As 1 Minute, is in proportion to 240 Minutes;
So is 17 Fathoms, to 4080 Fathoms, the Ships way in four hours.

The

The like is to be conceived, if your Glaſs be for any other quantity of time above or under a Minute.

Some have thought that the way which the Ship maketh, may be known to an old Sea-man by experience (as they ſay) that is, by conjecture; which Opinion makes ſome neglect the uſe of the *Log*, leſt they ſhould be accounted young Sea-men. But as he that rides often will have ſome near gueſs how far the pace he rides will carry him in an hour (becauſe he hath often obſerved it formerly;) ſo he which hath often ſailed, and kept an account of the Ships way by the *Log*, will be able to give ſome near eſtimate of her way without the *Log*. But it is incident to ſome men to have ſuch a conceit of this their eſtimate, that they think it more certain than the Rule it ſelf, from whence it is derived, eſpecially if it chance to anſwer their expectations at ſome times.

It is thought alſo that the Ships way may be known by two Marks on the Ships ſide, but this is doubtleſs very uncertain, both by reaſon of the ſhortneſs of the time, and in reſpect of the dead water (as they call it) by the Ships ſide. For the water which is near the Ship, is drawn along with the Ship in her motion, and ſo much the more, by how much it is nearer.

But if any deſire to make tryal of this way, it is to be conſidered, that 17 Foot is $\frac{1}{360}$ part of a mile, and 10 ſec. of a minute is $\frac{1}{360}$ part of an hour: Therefore if there be two Marks on the Ships ſide diſtant 17 Feet, if the Ship run the diſtance of theſe two Marks in 10 ſec. ſhe runs a mile in an hour, if in 5 ſec. two miles an hour, if ſhe runs that diſtance in 2 ſec. ſhe runs 5 miles in an hour. And ſo always dividing 10 ſec. by the number of ſec. in which the Ship runs in that diſtance, the Quotient ſhews the miles and parts of a mile run in an hour.

But if the diſtance of thoſe two Marks be 34 Feet, if ſhe run it in 20 ſec. it is after a mile an hour; if in 10 ſec. two miles an hour, if in 5 ſec. four miles an hour: and ſo always dividing 20 ſec. by the number of ſeconds, in which the Ship runs that diſtance, the Quotient ſhews how many miles the Ship runs in an hour. As if the Ship run that diſtance of 34 Feet in 8 ſec. then dividing 20 by 8, the Quotient is $2\frac{1}{2}$, ſhewing that ſhe runs $2\frac{1}{2}$ miles in an hour. Or, if you can conveneently make the diſtance of the two Marks on the Ships ſide to be 51 Feet (for the

further

further they are distant the better) then if the Ship run that distance in 30 sec. it is a mile an hour, if in 10 sec. it is 3 miles an hour; and so always dividing 30 sec. by the number of seconds, in which the Ship is running that distance, the Quotient shews after that rate how many miles the Ship runs in an hour.

Otherwise you may do thus, Divide 17 Feet into 10 parts, and set as many of those parts on the Ships side, as conveniently you may, which according to the Ships length will be more or fewer. Then when the Ship runs one of those parts in a sec. of time, it is a mile an hour; when two, it is two miles an hour; when five, it is five miles an hour. And in general, if you divide the number of parts run by the time of running accounted in sec. the Quotient shews what number of miles after that rate are run in an hour.

As if she run thirty of those parts in five seconds, it is six miles an hour; for dividing 30 by 5, the Quotient is 6; so if she run forty-two of those parts in 10 seconds, dividing 42 by 10, the Quotient is $4\frac{2}{10}$, which sheweth the Ships way at that time to be after the rate of four miles and two tenths of a mile in an hour.

But for keeping this account of time, it may be done either by a Sand-glass for that purpose, or by pronouncing certain words or numbers: as the time wherein a man tells twice 60, pronouncing every number as fast as he can conveniently and distinctly, is about a minute; so that the time wherein a man is numbring 60, is half a minute or 30 seconds; and whilst a man is numbring two (as one and twenty, two and twenty) is a second; and so whilst a man is numbring from twenty to thirty, is five seconds; from twenty to forty, ten seconds, *&c.* but in numbring from one and twenty, you may observe the same times as in numbring from one and twenty to forty, and this will not be hard to do; for whilst a man pronounceth one and twenty, two and twenty, three and twenty, *&c.* there remains a certain Impression in the Fantasie, whereby a man is able in the same times to pronounce one, two, three, *&c.* And although this Rule of numbring twice 60 for a minutes space be not general unto all men, because some are swifter or slower in their pronunciation than others; yet after this Example, a man making tryal, may frame a Rule to himself, whereby he may come something near the truth.

But

But leaving theſe, we come to the diviſion of the *Log-line*, according to the Half-minute-glaſs, which is more uſual and certain. And conſidering that half a minute is of an hour the $\frac{1}{120}$ part, therefore the Ships way running 51 Feet in half a minute, is a Mile an hour; if ſhe run twice ſo much, that is, 102 Feet in half a minute, it is two Miles an hour; if thrice ſo much, it is three Miles an hour: and in general, how many times 51 Feet ſhe runs in half a minute, ſo many miles is her way for an hour. Therefore leaving half a ſcore Fathoms, or more from the *Log*, that ſo it may be out of the Eddy of the Ships wake, before you begin to account or turn the Glaſs; if there you make a Mark for the beginning, and ſo 51 Feet from thence a Mark of one Knot, and 51 Feet further a Mark of two Knots, and 51 Feet farther (that is, 135 Feet from your firſt Mark) another Mark of three Knots; and ſo proceeding, look how many Knots are veered out in half a minute, ſo many miles is the Ships way for an hour. Now for that which is veered out more above the juſt meaſure of a Knot or Knots, you may allow for every five Feet the tenth part of a Mile almoſt. As admit ſhe run 5 Knots and 25 Feet in half a minute, then is her way according to $5\frac{1}{10}$, or 5 Miles and a half in an hour; if 6 Knots and 10 Feet, it is $6\frac{2}{10}$ Miles in an hour, *&c.*

But according to the common Opinion of 5000 Feet to a Mile, and 60 ſuch Miles to a Degree, there ſhould be ſomething leſs than 7 Fathom, namely, $41\frac{2}{3}$ Feet to a Knot.

And although he which veers the *Log-line* be careful to overhale it ſo ſlack, that it may not draw forwards the *Log*, yet (no doubt) it doth loſe ſome way, following the Ship a little as it is drawn by the Line, and withal by the Eddy of the Ships wake, and ſometimes alſo is caſt forwards by the Wind and Waves, when they come after the Ship: ſo that for theſe cauſes, it is like, there may ſometimes be allowed three or four Fathoms more than is veered out; but this (as a thing mutable and uncertain) being ſometimes more, ſometimes leſs, cannot be brought to any certain Rule, but ſuch allowance may be made as a man in his experience and diſcretion finds fit.

If you would divide the *Log-line* ſo as it might give the Ships way in *Centeſms*, or the hundredth part of a degree, and fit it to a Half-minute-glaſs; Then ſeeing the hundredth part of a degree

3672 Feet, and the $\frac{1}{120}$ part thereof is $3\frac{1}{5}$ Feet; if you begin at the mark at which you mean to turn the Glass, and measure from thence 30 Feet, and three fifth parts of a Foot, you may there place 1 Knot; and thence again measuring 30 Feet, and three fifth parts of a Foot, there place two Knots; and so proceeding at the end of every 30 Feet and three fifths, adding a Knot, the number of Knots which run out in half a minute, is the number of *Centesms* which the Ship runs in an hour. As suppose there run out 10 Knots in half a minute, then the Ships way according to 10 *Centesms* to a degree in an hour, that is, the tenth part of a degree, or 6 miles. And so every 3 Foot above the just measure of Knots, is near the tenth part of a *Centesm*, or the hundredth part of a degree. As if there run out of the *Log-line* 5 Knots and 12 Feet, then the Ships way for an hour is 5 *Centesms*, and four tenth parts of a *Centesm*: the like is to be understood of others.

And after the form of these Examples you may divide the *Log-line* for any other quantity of Time, more or less than half a minute, or for any other parts of a degree proposed.

Thus have we handled the Division of the *Log-line*, according to the measure before found of 367200 *English*-Feet in a degree. But because (as I have before shewed) the Ships way is commonly more than by the *Log-line* it appears to be, and every man desires to have his reckoning something before his Ship, that he fall not with a place unexpected; for these, and such other causes, and for the rotundity of the number, if any man think it more safe and convenient in Sea-reckonings, he may abate one in 51, and so assign to a degree only 360000 Feet, and consequently to a mile 6000 *English*-Feet.

And upon this ground, if in half a minute there run out 50 Feet of the *Log-line*, it is a mile an hour; and so if 100 Feet run out in a minute.

For, As 1 minute is in proportion to 60 minutes;

So is 100 Feet to 6000 Feet.

And so forasmuch as 25 Feet is $\frac{1}{240}$ part of a mile, and 15 seconds is also $\frac{1}{240}$ part of an hour. Therefore if there be two Marks of the Ships side distant 25 Feet, if the Ship run the distance of these two Marks in 15 seconds, it is after the rate of a mile an hour; if in 5 seconds, it is 3 miles an hour; and so always dividing

dividing 15 ſeconds by the number of ſeconds in which the Ship runs that diſtance; the Quotient ſhews the miles and parts of a mile run in an hour. But if the diſtance of theſe two Marks be 50 Foot, then if ſhe run 30 ſeconds, or half a minute, it is a mile an hour; if in 10 ſeconds, three miles an hour; if in five ſeconds, ſix miles an hour, (for 30 divided by 5, the Quotient is 6.) And ſo always dividing 30 ſeconds by the number of ſeconds, in which the Ship runs that Diſtance; the Quotient ſhews how many miles ſhe runs in an hour, *&c.*

Otherwiſe, if you make a mark on the Ships ſide at every 20 Inches, then when the Ship runs one of theſe parts in a ſecond of time, it is a mile an hour; when five, it is five miles an hour; if ſhe run eighteen of theſe parts in three ſeconds, it is ſix miles an hour. For dividing 18 by 3, the Quotient is 6. And in general, if you divide the number of the parts run, by the number of ſeconds ſpent in running, the Quotient ſhews the Ships way in miles for an hour.

But for dividing the *Log-line* according to this ground of 6000 Feet in a Mile, if you intend to uſe it with a Half-minute-glaſs, then becauſe half a minute is $\frac{1}{120}$ part of an hour, and 50 Feet is alſo the $\frac{1}{120}$ part of a mile; therefore when the Ship runs 50 Feet in half a minute, her way is after the rate of a mile an hour; if 100 Feet in half a minute, it is two miles an hour, *&c.*

Therefore half a ſcore Fathoms or more from the *Log*, you may make a Mark, and beginning from thence meaſure 50 Feet, and and there make the firſt Knot, and 50 Foot farther two Knots, and 50 Foot farther three Knots: And ſo proceeding, look how many Knots is run out in half a minute, ſo many miles is the Ships way for an hour: and every 5 Feet more beſides the Knots, is a tenth part of a mile; as if there run out 6 Knots and 20 Feet in half a minute, the Ships way is after the rate of $6\frac{4}{10}$ miles in an hour, *&c.*

And if the Glaſs were for any other time more or leſs than half a minute, you may make the diſtance of your Knots proportional: As if it were for 20 ſeconds, then becauſe 20 ſeconds is of an hour the $\frac{1}{180}$ part, I divide a mile, which is 6000 Feet, by 180, and the Quotient is $33\frac{1}{3}$; therefore there muſt be a Knot at every 33 Feet and 4 Inches.

If your Glaſs be 36 ſeconds, which is $\frac{1}{100}$ part of an hour, divide 6000 by 100, the Quotient is 6; ſhewing that there muſt be 60 Feet to every Knot; and then every 6 Foot over and above the Knots, is a tenth part of a Mile more.

And ſo it is better that your Glaſs be more than half a minute, rather than leſs; and the more the better, provided that there run out no more Line than you may hale in again, without danger of breaking.

Laſtly, if you would ſo divide the *Log-line*, that it might ſhew the Ships way in *Centeſms* of a degree, and fit it to an Half-minute-glaſs. Then foraſmuch as the hundredth part of a degree is 360 Feet, and the $\frac{1}{120}$ part thereof is 30 Feet; therefore beginning at the Mark whereat you intend to turn the Glaſs, meaſure from thence 30 Feet, and there make one Knot, and at 30 Feet farther two Knots, *&c.* Then look how many Knots run out in half a minute, ſo many *Centeſms* of a degree is the Ships way for an hour. And ſo if the Glaſs be 36 ſeconds, then every Knot muſt have 36 Feet, *&c.*

Now if a man Sailing between any two places which lie near Eaſt and Weſt one from another, have kept his Reckoning by Courſe and Diſtance, uſing a *Log-line* ſo divided, that it have a Knot at every 7 Fathoms (as many do) and would reduce the Diſtance of thoſe two places ſo found, to their Diſtance in ſuch Miles, as theſe of 60 to a degree, each containing (as we have ſaid) 6000 Feet; the proportion in number of thoſe to theſe, is as 6 to 5, for ſix of them make five of theſe.

As admit a man in his Dead-reckoning, uſing ſuch a *Log-line* as hath a Knot at every 7 Fathoms, and for every Knot running out in half a minute, he accounts the Ships way to be ſo many Miles an hour; and according to ſuch a Reckoning, ſuppoſe he find the Diſtance of two places to be 1224 Miles, or 408 Leagues, and would know the Diſtance of the ſame places in Miles of 6000 Feet to a Mile, which is according to a *Log-line* that hath a Knot at every 50 Feet. Say then by the Rule of Proportion:

As the number 6 *Co. ar.*	9.22185
is in proportion to 5	0.69897
So is the number of Miles given, 1224	3.08778
to the number of miles required, 1020	3.00860

Which

Which 1020 is the Diſtance of thoſe two places, in ſuch Miles whereof 6 make a deg. Or to find the ſame in Leagues, the Proportion is: As 6 to 5; ſo is 408 Leagues, to 340 Leagues.

And thus may the Diſtances of Places be found in ſuch Miles, whereof 60 make a deg. eſpecially if with the Diſtance expreſſed in the *Plain Chart*, you compare the Reckonings of ſome skilful Mariners that have ſailed from the one to the other. But thus to endeavour a reformation of the *Plain Chart*, were a Labour to little purpoſe; for there the correcting of the true ſituation of two places, in reſpect of one another, is oftentims an occaſion that the ſame places are the more falſly ſituate in reſpect of others. Like as if there were two places 8 Miles diſtant, and it were required to place a third three Miles from either of them; here, if we ſet the third in the middle, it will be four Miles diſtant from either: But if (attempting to mend that Error) we make the third to be three Miles from the firſt, then will it be five Miles from the ſecond. And thus unavoidably, the mending of the one is the marring of the other, becauſe the thing propoſed is not poſſible.

And ſuch is the Error of the plain or common *Sea-Chart*, repreſenting the Earth and Sea, not as a Spherical, but as a Plain *Superficies*; not as if the Meridians did concur in the Poles, but as if they were always parallel one to another. So that the Graduation and Projection being ſuch, the Situations and Diſtances of places cannot be generally and truly expreſſed therein.

But the Graduation and Projection of *Mercator's Chart*, agreeing without ſenſible Error with the *Globe*, there may in that be deſcribed all or any parts of the World, according to their Longitudes, Latitudes, Courſes and Diſtances, as truly, and far more conveniently for the Mariner's uſe than upon the *Globe* it ſelf; and upon ſuch a *Chart* ſo deſcribed, a Reckoning may be truly kept, and any Error committed may eaſily be diſcerned and amended. Whereas on the *Plain Chart*, if a man find his Reckoning to diſagree, he is ſo far from knowing how to amend it, that he can ſeldom conjecture where the fault was.

The neglect and want of theſe *Charts*, hath been, and is a great imperfection in *Navigation* and *Geography*. For howſoever there be ſome which do daily ſet forth for ſale Maps of the World, and of the parts thereof, according to this Projection, yet to have them

them truly ſuch, and fit for *Navigation*, requires in the Author or Maker of them good knowledge, and ſome competent ability of his own, or ayd from others, with a greater love to the Truth, than to his own Profit, which may induce him to beſtow ſuch Induſtry, Time and Expence, as I have formerly noted to be requiſite in ſuch a Work.

For the furtherance whereof, and of the Practice of *Navigation* in general, I ſhall endeavour in the two next Chapters to ſhew a methodical and orderly way of keeping a reckoning at Sea, more diſtinctly and exactly than hath been formerly uſed, and ſuch as may aptly be ſet down in any *Chart*, and applied in the three principal kinds of Sailing; namely, according to the *Plain Chart*, or *Mercator*'s, or according to the Arch of a *Great Circle*. And by a few Reckonings truly ſet down, according to this form, the Maps of the World, and of the parts thereof, might be much reformed.

CHAP. VIII.

A formal and exact way of ſetting down and perfecting Sea-reckoning.

ALthough the Courſe and Diſtance cannot be ſo truly and certainly known as the Latitude may be; yet we muſt endeavour in theſe alſo to come as near the Truth as may be, the rather, for that ſome Reckonings muſt neceſſarily depend wholly upon them. And to that end, thoſe which in their Voyages at Sea, have occaſion to run far upon any Courſe or Courſes near the Meridian, may do well to make tryal of that which I have formerly ſet down, touching the quantity of a degree of the Earth and Sea in our known meaſure; and eſpecially in the *Eaſt-Indian* Voyages; ſailing from the *Lizard* in the Weſt part of *England*, to *Cape bon Eſperance* in *Africk*, they have opportunity of making an ample Experiment hereof.

But leaving this to the Practice of the skilful and induſtrious *Sea-man*, we come now to ſhew an orderly and exact way of framing

framing and keeping a Reckoning at Sea; for which purpoſe I have made the Table following, which ſheweth how much a Ship is more Northerly or Southerly, and how much more Eaſterly or Weſterly, by Sailing upon any Point or half Point of the *Compaſs*, any number of Miles propoſed.

The like Table I made many years ſince, and taught the Uſe of it in *Navigation*; whether it were then uſed by any other, I know not, I had it of no man; but this I ſpeak, that if any man claim the firſt making and uſe of ſuch an one, he may have it.

The Ground of making this Table is the ſame with the former. *For as* Radius *is in proportion to the Diſtance run, So is the* Sine Complement *of the* Rumb, *to the Diſtance of North or South; and ſo is the* Sine *of the* Rumb, *to the Diſtance of Eaſt or Weſt.* Therefore here for 10 miles upon any of the four Points from the Meridian, we ſet in the ſecond Column the Sine Complement of that Point (reduced into degr.) and in the third the Sine thereof. As the ſecond Rumb or Point from the Meridian, being 22 degr. 30 min. the Sine Complement thereof which is 9239 ſet in the ſecond Column againſt 10; and the Sine thereof 3827, I ſet in the third Column: and having done this for 10 miles in every Column, the reſt may be eaſily drawn from them.

As in the ſecond Column, for the firſt half Point againſt 10 miles, finding 9952, I ſet the half thereof namely, 4976 againſt 5 miles, and the tenth part thereof, namely, 995 againſt one mile, which doubled or added to it ſelf, is 1990, to be ſet againſt 2 miles, whereto adding the ſame 995, the Sum is 2985 for 3 miles; and ſo for the reſt.

And thus for every Point and half Point from the Meridian, there are three Columns: In the firſt whereof, there is ſet down a number of Miles run upon that Point or half Point; the ſecond ſheweth how much the Latitude is altered, that is, how much more you are Southerly or Northerly, by running ſo far upon that Point or half Point; the third, how much you are more Eaſterly or Weſterly, by running that Courſe and Diſtance.

The-

The numbers ſet in every firſt Columns from 1 to 10, are alſo to be underſtood from 10 to 100, or from 100 to 1000, and the Figure in the fourth place of the ſecond and third Columns, anſwer to the firſt. As admit a Ship run South and by Weſt, (that is, South, one Point Weſterly, 165 Miles) I ſet down this number thus; and looking in the Columns of the firſt Rumb againſt 10 (which may be underſtood to be 100) I find againſt it in the ſecond Column 981 almoſt, and in the third 195, as alſo againſt 6 (that is, 6) in the firſt Column, there is 588 in the ſecond, and 117 in the third: alſo againſt 5 in the firſt Column, there is 49 in the ſecond, and almoſt 10 in the third.

	100	981	195
S.W. 1.	60	588	117
point.	5	49	10
	165	161.8	32.2

Theſe ſet down, and ſumm'd up as here appeareth, ſhew that a Ship running *S.* by *W.* 165 Miles, is to the Southwards of the place from whence ſhe departed 161 Miles, and 8 Tenth parts of a Mile; and to the Weſtwards 32 Miles, and 2 Tenth parts of a Mile. If you deſire more exactneſs, you may uſe all the places for the firſt or greateſt number, which is here 100.

	100	9809	1950
S.W. 1.	65	5885	1170
point.	5	490	97
	165	161.83	32.17

As in this ſecond Example, where the Southerly Diſtance is 161 $\frac{83}{100}$ Miles, and the Weſterly 32 $\frac{17}{100}$ Miles.

A Table

A Table of the Northing or Southing, Easting or Westing of every Rumb and half Rumb from the Meridian; according to the number of Miles run upon that Rumb.

	½ point.	7½ poin.	1 point.	7 point.	1½ poin.	6½ poin.	2 point.	6 point.
M.	5. 37½	84. 22½	11. 15.	78. 45	16. 52	73. 7½	22. 30	67. 30
1	995	98	981	195	957	290	924	383
2	1990	196	1962	390	1914	580	1848	766
3	2986	294	2943	585	2871	870	2772	1148
4	3981	392	3923	780	3827	1161	3696	1531
5	4976	490	4904	975	4784	1451	4620	1914
6	5971	588	5885	1170	5741	1741	5544	2297
7	6966	686	6866	1365	6698	2031	6468	2680
8	7961	784	7846	1560	7655	2321	7392	3062
9	8957	882	8827	1755	8612	2612	8315	3445
10	9952	980	9808	1950	9569	2902	9239	3827

	2½ poin.	5½ poin.	3 point.	5 point.	3½ poin.	4½ poin.	4 point.	4 point
M.	28. 7½	61. 52½	33. 45	56. 15	39. 22½	50. 37½	45. 00	45. 00
1	882	471	831	556	773	634	707	707
2	1764	942	1663	1111	1546	1269	1414	1414
3	2646	1414	2494	1667	2319	1903	2121	2121
4	3528	1885	3326	2222	3092	2538	2828	2828
5	4410	2357	4158	2778	3865	3172	3535	3535
6	5292	2828	4989	3334	4638	3806	4242	4242
7	6174	3300	5820	3890	5411	4440	4949	4949
8	7056	3771	6652	4445	6184	5075	5656	5656
9	7937	4243	7483	5000	6957	5710	6364	6364
10	8819	4714	8315	5556	7730	6344	7071	7071

A larger Example may be that before set down in the last Problem of Sailing by a Great Circle, from *Summers Islands* to the *Lizard*, Pag. 170. of *The Doctrine of Triangles.*

As admit I ſail from thence; Firſt, $NE\frac{1}{2}$ Point Eaſterly 600 miles, then NE by E 300 miles; ENE half a Point Northerly 495 miles; ENE 390 miles; $ENE\frac{1}{2}$ Point Eaſterly 264 miles; N by E 210 miles; Eaſt 951 miles. Theſe Courſes and Diſtances I ſet down in ſuch form as here appeareth, where in the firſt Column there is expreſſed the Courſe or Point of the Compaſs upon which a man ſails; in the ſecond Column, the Diſtance of the Rumb from the Meridian; in the third Column, the Diſtance run upon that Point; in the reſt, the Difference of Latitude, and Departure from the Meridian in Miles, and tenth parts of a Mile.

Courſe.	*Rumb from the*	*Diſt. miles.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
$NE\frac{1}{2}$ Po. *E.*	*North Eaſterly.* $4\frac{1}{2}$.	600	380.6		4638	
NE by *E.*	*N Eaſt* 5 Point.	300	166.7		2494	
$ENE\frac{1}{2}$ Po. *N.*	*N. Eaſt* $5\frac{1}{2}$ Po.	400 90 5	1885 424 24		3528 794 44	
ENE	*N Eaſt* 6 Point.	300 90	1148 344		277.3 831	
$ENE\frac{1}{2}$ Po. *E.*	*N E aſt* $6\frac{1}{2}$ Point	200 60 4	580 174 12		1914 574 38	
E by *N.*	*N Eaſt* 7 Point.	200 10	390 20		1962 98	
Eaſt.	*Eaſt.*	900 50 1			9510	
		3210	1047.4		22197	

(In all which it is conceived, that all the *Variations* are allowed) ſo that at the Foot of this Reckoning, I find the Sum of the North Column

Column to be 1047 $\frac{4}{10}$ miles, and the Sum of the East Column 2910 miles almost; the first, namely, 1047 miles converted into deg. is 17 deg. 27 min. the difference of Latitude, which added to the Latitude of *Summer Islands* 32 deg. 25 min. (where this Reckoning began) the Sum is 49 deg. 52 min. which is the Latitude of this place where this Reckoning endeth. So that according to this Account, the Ship is run into the Latitude of 49 deg. 52 min. and hath altered her Longitude to the Eastwards 2920 miles, of such miles, whereof 60 make a degr. of a great Circle.

Therefore if you set down this Reckoning on the *Plain Chart*, you must make a Point in the *Chart* that may be in the Latitude of 49 deg. 52 min. and to the Eastwards of *Summer Islands*, (where this Reckoning began) 2920 miles, that is, you must run a Parallel (with your Compasses or otherwise) on your *Chart* in the Latitude of 49 deg. 52 min. and cross the same by a Meridian, which may be to the Eastwards of the Meridian of *Summer Islands* 2920 miles; and so the Point of the Intersection of this Parallel and Meridian, is the Traverse-Point, or Point in the *Chart* representing the place where the Ship is in the end of this Reckoning.

But if you set down this Reckoning on *Mercator's Chart*, you must also find a Point that may be in the Latitude of 49 deg. 52 min. and may likewise be to the Eastwards of *Summer Islands* 2920 miles, which is done by running with your Compasses a Parallel in the Latitude of 49 deg. 52 min. and crossing the same by a Meridian, which may be to the Eastwards of the Meridian of *Summer Islands*, 2920 miles, the Point of the Intersection of this Parallel with that Meridian, is the Traverse-Point, representing in the *Chart* the place where the Ship is.

For it is to be conceived in this *Chart*, that the degrees of the Meridian intercepted between the Latitude of two places, are as a Scale for those two places, to measure not only their difference of Latitude, but likewise their Distance in their Rumb, as also the Distance of their Meridians.

But because it often falls out, that in Sailing from place to place, a Ship runs not near the Rumb of two places by many hundred miles, especially in Sailing by the Arch of a Great Circle, which is the most exquisite manner of Sailing, and wherein a man shifts his Course often, and runs much farther in one Latitude than

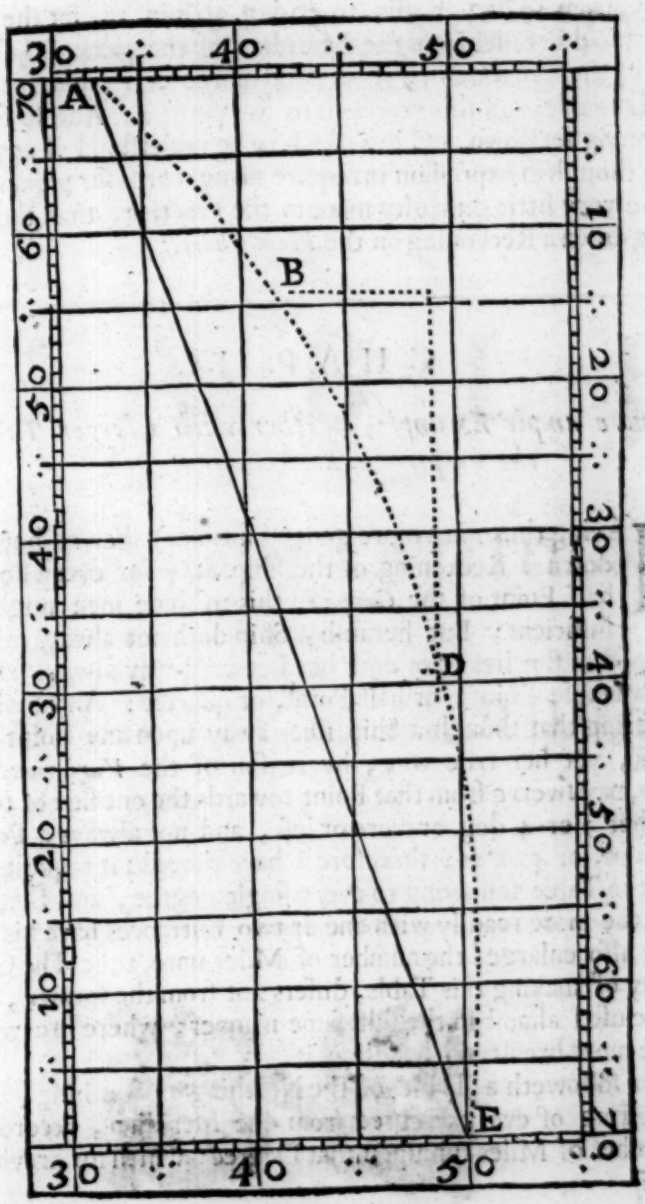
in another, as by the former Example may appear. Therefore once in three or four days, or ſo often as you alter your Courſe much, you may transfer or ſet down your Reckoning out of your Book into your *Chart*. As in transferring the former Example, you may ſet down the Northing and Eaſting of every of the Courſes ſeverally; but for brevity ſake we will bring them into three parts; and ſo alſo we ſhall not much erre.

And thus for the two firſt Courſes, namely, *N. E.* $\frac{1}{2}$ Point Eaſterly 600 miles, and *N. E.* by *E.* 300 miles, I find in the North Column 547 miles, and in the Eaſt Column 713 miles; alſo for the three next Courſes, ſumming up the North and Eaſt Columns, I find the Northing to be 459 miles; and the Eaſting 1050 miles. Alſo for the two laſt Courſes, I find the Northing to be 41 miles, and the Eaſting 1157 miles.

North.	*Eaſt.*
547	713
459	1050
41	1157
1047	2920

Now to transfer theſe into the *Chart*, I conſider that 547 miles is 9 deg. 7 min. which added to the former Latitude 32 deg. 25 min. makes Latitude 41 deg. 32 min. In which Latitude I run a Parallel; then conſidering that 713 miles is 11 deg. 53 min. I take this 11 deg. 53 min. in the Meridian, as much above the one Latitude, as beneath the other, namely, from 31 deg. 0 min. to 42 deg. 53 min. and this I ſet in the foreſaid Parallel from the Meridian of *Summers Iſlands* to the Eaſtwards, and there make the Point *B*, then reducing 459 miles into degr. it makes 7 deg. 39 min. which added to 41 deg. 32 min. makes Latitude 49 deg. 11 min. Alſo the Eaſting 1050 miles are 17 deg. 30 min. the half whereof 8 deg. 45 min. I take in the Meridian from above 41. deg. 32 min. beneath 49 deg. 11 min. namely, from 41 deg. 20 min. to 50 deg. 5 min. And this being doubled (becauſe it is but the half) I ſet from the Meridian of the Prick or Traverſe-point *B* before made, in the Parallel of 49 deg. 11 min. making there another prick *D*. Laſtly, I add the Northing 41 miles to the former Latitude 49 deg. 11 min. the ſum is 49 deg. 52 min. the Latitude of the Parallel to which I am now come, wherein I am to ſet down the Eaſting 1157 miles. This therefore converted into degrees of a great Circle, make 19 degr. 17 min. I take therefore 1 deg. of the Meridian, about that Latitude

of


30
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60
70
80
A
B
D
E
30
40
50

of 49 deg. 52 min. (becauſe the moſt part is run in that Latitude) namely, from 49 deg. 30 min. to 50 deg. 30 min. and ſet the ſame in the foreſaid Parallel from the Meridian of the prick *D* laſt before made to the Eaſtwards 19 times; and moreover 17 min. take at the ſame Latitude, and this reacheth to the point *E*. And ſo is all this Reckoning ſet down, and the like is to be underſtood of any other, which though in expreſſion it require many words for plainneſs, yet is there very little difficulty more in the Practice, than there is in ſetting down a Reckoning on the *Plain Chart*.

CHAP. IX.

A more ample Example, together with a larger Table for the keeping a Reckoning at Sea.

HAving thus (in a more general manner) ſhewed how to ſet down a Reckoning of the Ships way for every Point and half Point of the *Compaſs*, this to ſome men might ſeem ſufficient; But becauſe a Ship doth not always make her way good as ſhe lies, nor doth her Leeward-way always fall juſtly upon a whole Point, or half-Point, or quarter: And moreover, conſidering that though a Ship ſteer away upon any Point of the *Compaſs*, yet her true way, by reaſon of the *Variation* of the *Needle*, may ſwerve from that Point towards the one ſide or towards the other 3 or 4 deg. or more or leſs, and not always a Point, or half-Point, or quarter; therefore I have thought it requiſite to ſet down the Table following to every ſingle degree, and that a man might the more readily with one or two Entrances have his deſire, I have alſo enlarged the number of Miles unto 100. The Ground and way of making this Table, differs not from the former, and it is to be uſed almoſt in the ſelf ſame manner; wherefore we ſhall uſe the more brevity in handling it.

Here followeth a Table of the Northing or Southing, Eaſting or Weſting of every Degree from the Meridian, according to the number of Miles run upon that Degree; which for brevity ſake we call

A

TABLE

FOR THE

DIFFERENCE of LATITUDE,

AND

DEPARTURE from the MERIDIAN.

1 Deg.

Dist.	1 Deg. Lat.	Dep.
1	1.0	0
2	2.0	0
3	3.0	0
4	4.0	1
5	5.0	1
6	6.0	1
7	7.0	1
8	8.0	1
9	9.0	2
10	10.0	2
11	11.0	2
12	12.0	2
13	13.0	2
14	14.0	2
15	15.0	3
16	16.0	3
17	17.0	3
18	18.0	3
19	19.0	3
20	20.0	4
21	21.0	4
22	22.0	4
23	23.0	4
24	24.0	4
25	25.0	4
26	26.0	5
27	27.0	5
28	28.0	5
29	29.0	5
30	30.0	5
31	31.0	5
32	32.0	6
33	33.0	6
34	34.0	6
Dist.	Dep.	Lat.

89 Deg.

Dist.	1 Deg. Lat.	Dep.
35	35.0	6
36	36.0	7
37	37.0	7
38	38.0	7
39	39.0	7
40	40.0	7
41	41.0	7
42	42.0	7
43	43.0	8
44	44.0	8
45	45.0	8
46	46.0	8
47	47.0	8
48	48.0	9
49	49.0	9
50	50.0	9
51	51.0	9
52	52.0	9
53	53.0	9
54	54.0	1.0
55	55.0	1.0
56	56.0	1.0
57	57.0	1.0
58	58.0	1.0
59	59.0	1.0
60	60.0	1.1
61	61.0	1.1
62	62.0	1.1
63	63.0	1.1
64	64.0	1.1
65	65.0	1.2
66	66.0	1.2
67	67.0	1.2
68	68.0	1.2
Dist.	Dep.	Lat.

89 Deg.

Dist.	1 Deg. Lat.	Dep.
69	69.0	1.2
70	70.0	1.2
71	71.0	1.3
72	72.0	1.3
73	73.0	1.3
74	74.0	1.3
75	75.0	1.3
76	76.0	1.3
77	77.0	1.4
78	78.0	1.4
79	79.0	1.4
80	80.0	1.4
81	81.0	1.4
82	82.0	1.4
83	83.0	1.5
84	84.0	1.5
85	85.0	1.5
86	86.0	1.5
87	87.0	1.5
88	88.0	1.5
89	89.0	1.6
90	90.0	1.6
91	91.0	1.6
92	92.0	1.6
93	93.0	1.6
94	94.0	1.7
95	95.0	1.7
96	96.0	1.7
97	97.0	1.7
98	98.0	1.7
99	99.0	1.7
100	100.0	1.8
200	200.0	3.5
300	300.0	5.3
Dist.	Dep.	Lat.

89 Deg.

Dist.	2 Deg. Lat.	Dep.
1	1.0	.0
2	2.0	.1
3	3.0	.1
4	4.0	.1
5	5.0	.2
6	6.0	.2
7	7.0	.2
8	8.0	.3
9	9.0	.3
10	10.0	.3
11	11.0	.4
12	12.0	.4
13	13.0	.4
14	14.0	.5
15	15.0	.5
16	16.0	.6
17	17.0	.6
18	18.0	.6
19	19.0	.7
20	20.0	.7
21	21.0	.7
22	22.0	.8
23	23.0	.8
24	24.0	.8
25	25.0	.9
26	26.0	.9
27	27.0	.9
28	28.0	1.0
29	29.0	1.0
30	30.0	1.0
31	31.0	1.1
32	32.0	1.1
33	33.0	1.1
34	34.0	1.2
Dist.	Dep.	Lat.

88 Deg.

Dist.	2 Deg. Lat.	Dep.
35	35.0	1.2
36	36.0	1.3
37	37.0	1.3
38	38.0	1.3
39	39.0	1.4
40	40.0	1.4
41	41.0	1.4
42	42.0	1.5
43	43.0	1.5
44	44.0	1.5
45	45.0	1.6
46	46.0	1.6
47	47.0	1.6
48	48.0	1.7
49	49.0	1.7
50	50.0	1.7
51	51.0	1.8
52	52.0	1.8
53	53.0	1.8
54	54.0	1.9
55	55.0	1.9
56	56.0	1.9
57	57.0	2.0
58	58.0	2.0
59	59.0	2.0
60	60.0	2.1
61	61.0	2.1
62	62.0	2.2
63	63.0	2.2
64	64.0	2.2
65	65.0	2.3
66	66.0	2.3
67	67.0	2.3
68	68.0	2.4
Dist.	Dep.	Lat.

88 Deg.

Dist.	2 Deg. Lat.	Dep.
69	69.0	2.4
70	70.0	2.4
71	71.0	2.5
72	72.0	2.5
73	73.0	2.5
74	74.0	2.6
75	75.0	2.6
76	76.0	2.6
77	77.0	2.7
78	78.0	2.7
79	79.0	2.8
80	80.0	2.8
81	80.9	2.8
82	81.9	2.9
83	82.9	2.9
84	83.9	2.9
85	84.9	3.0
86	85.9	3.0
87	86.9	3.0
88	87.9	3.1
89	88.9	3.1
90	89.9	3.1
91	90.9	3.2
92	91.9	3.2
93	92.9	3.2
94	93.9	3.3
95	94.9	3.3
96	95.9	3.4
97	96.9	3.4
98	97.9	3.4
99	98.9	3.5
100	99.9	3.5
200	199.8	7.0
300	299.7	10.5
Dist.	Dep.	Lat.

88 Deg.

Dif.	3 Deg. Lat.	Dep.
1	1.0	.1
2	2.0	.1
3	3.0	.1
4	4.0	.2
5	5.0	.2
6	6.0	.3
7	7.0	.4
8	8.0	.4
9	9.0	.5
10	10.0	.5
11	11.0	.6
12	12.0	.6
13	13.0	.7
14	14.0	.7
15	15.0	.8
16	16.0	.8
17	17.0	.9
18	18.0	.9
19	19.0	1.0
20	20.0	1.0
21	21.0	1.1
22	22.0	1.1
23	23.0	1.2
24	24.0	1.2
25	25.0	1.3
26	26.0	1.3
27	27.0	1.4
28	28.0	1.5
29	29.0	1.5
30	30.0	1.6
31	31.0	1.6
32	32.0	1.7
33	33.0	1.7
34	34.0	1.8
Dif.	Dep.	Lat.

87 Deg.

Dif.	3 Deg. Lat.	Dep.
35	35.0	1.8
36	36.0	1.9
37	37.0	1.9
38	38.0	2.0
39	39.0	2.0
40	40.0	2.1
41	41.0	2.1
42	42.0	2.2
43	43.0	2.2
44	44.0	2.3
45	45.0	2.3
46	46.0	2.4
47	47.0	2.4
48	48.0	2.5
49	49.0	2.6
50	50.0	2.6
51	50.9	2.7
52	51.9	2.7
53	52.9	2.8
54	53.9	2.8
55	54.9	2.9
56	55.9	2.9
57	56.9	3.0
58	57.9	3.0
59	58.9	3.1
60	59.9	3.1
61	60.9	3.2
62	61.9	3.2
63	62.9	3.3
64	63.9	3.3
65	64.9	3.4
66	65.9	3.5
67	66.9	3.5
68	67.9	3.6
Dif.	Dep.	Lat.

87 Deg.

Dif.	3 Deg. Lat.	Dep.
69	68.9	3.6
70	69.9	3.7
71	70.9	3.7
72	71.9	3.8
73	72.9	3.8
74	73.9	3.9
75	74.9	3.9
76	75.9	4.0
77	76.9	4.0
78	77.9	4.1
79	78.9	4.1
80	79.9	4.2
81	80.9	4.2
82	81.9	4.3
83	82.9	4.3
84	83.9	4.4
85	84.9	4.4
86	85.9	4.5
87	86.9	4.5
88	87.9	4.6
89	88.9	4.6
90	89.9	4.7
91	90.9	4.8
92	91.9	4.8
93	92.9	4.9
94	93.9	4.9
95	94.9	5.0
96	95.9	5.0
97	96.9	5.1
98	97.9	5.1
99	98.9	5.2
100	99.9	5.2
200	199.7	10.5
300	299.6	15.7
Dif.	Dep.	Lat.

87 Deg.

Dist.	4 Deg. Lat.	Dep.	Dist.	4 Deg. Lat.	Dep.	Dist.	4 Deg. Lat.	Dep.
1	1.0	.1	35	34.9	2.5	69	68.8	4.8
2	2.0	.1	36	35.9	2.5	70	69.8	4.9
3	3.0	.2	37	36.9	2.6	71	70.8	4.0
4	4.0	.3	38	37.9	2.7	72	71.8	5.0
5	5.0	.3	39	38.9	2.7	73	72.8	5.1
6	6.0	.4	40	39.9	2.8	74	73.8	5.2
7	7.0	.5	41	40.9	2.9	75	74.8	5.2
8	8.0	.6	42	41.9	2.9	76	75.8	5.3
9	9.0	.6	43	42.9	3.0	77	76.8	5.4
10	10.0	.7	44	43.9	3.1	78	77.8	5.5
11	11.0	.8	45	44.9	3.1	79	78.8	5.5
12	12.0	.8	46	45.9	3.2	80	79.8	5.6
13	13.0	.9	47	46.9	3.3	81	80.8	5.7
14	14.0	1.0	48	47.9	3.4	82	81.8	5.7
15	15.0	1.0	49	48.9	3.4	83	82.8	5.8
16	16.0	1.1	50	49.9	3.5	84	83.8	5.9
17	17.0	1.2	51	50.9	3.6	85	84.8	5.9
18	18.0	1.3	52	51.9	3.6	86	85.8	6.0
19	19.0	1.3	53	52.9	3.7	87	86.8	6.1
20	20.0	1.4	54	53.9	3.8	88	87.8	6.1
21	20.9	1.5	55	54.9	3.8	89	88.8	6.3
22	21.9	1.5	56	55.9	3.9	90	89.8	6.3
23	22.9	1.6	57	56.9	4.0	91	90.8	6.4
24	23.9	1.7	58	57.9	4.0	92	91.8	6.5
25	24.9	1.7	59	58.9	4.1	93	92.8	6.5
26	25.9	1.8	60	59.9	4.2	94	93.8	6.6
27	26.9	1.9	61	60.9	4.3	95	94.8	6.6
28	27.9	2.0	62	61.9	4.3	96	95.8	6.7
29	28.9	2.0	63	62.9	4.4	97	96.8	6.8
30	29.9	2.1	64	63.9	4.5	98	97.8	6.8
31	30.9	2.2	65	64.8	4.5	99	98.8	6.9
32	31.9	2.2	66	65.8	4.6	100	99.8	7.0
33	32.9	2.3	67	66.8	4.7	200	199.5	14.0
34	33.9	2.4	68	67.8	4.8	300	299.3	20.9
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
	86 Deg.			86 Deg.			86 Deg.	

Dif.	5 Deg. Lat.	Dep.
1	1.0	.1
2	2.0	.2
3	3.0	.3
4	4.0	.3
5	5.0	.4
6	6.0	.5
7	7.0	.6
8	8.0	.7
9	9.0	.8
10	10.0	.9
11	11.0	1.0
12	12.0	1.0
13	13.0	1.1
14	14.0	1.2
15	15.0	1.3
16	15.9	1.4
17	16.9	1.5
18	17.9	1.6
19	18.9	1.7
20	19.9	1.7
21	20.9	1.8
22	21.9	1.9
23	22.9	2.0
24	23.9	2.1
25	24.9	2.2
26	25.9	2.3
27	26.9	2.4
28	27.9	2.4
29	28.9	2.5
30	29.9	2.6
31	30.9	2.7
32	31.9	2.8
33	32.9	2.9
34	33.9	3.0
Dif.	Dep.	Lat.
	85 Deg.	

Dif.	5 Deg. Lat.	Dep.
35	34.9	3.0
36	35.9	3.1
37	36.9	3.2
38	37.9	3.3
39	38.8	3.4
40	39.8	3.5
41	40.8	3.6
42	41.8	3.7
43	42.8	3.7
44	43.8	3.8
45	44.8	3.9
46	45.8	4.0
47	46.8	4.1
48	47.8	4.2
49	48.8	4.3
50	49.8	4.4
51	50.8	4.5
52	51.8	4.5
53	52.8	4.6
54	53.8	4.7
55	54.8	4.8
56	55.8	4.9
57	56.8	5.0
58	57.8	5.1
59	58.8	5.2
60	59.8	5.2
61	60.8	5.3
62	61.8	5.4
63	62.8	5.5
64	63.8	5.6
65	64.8	5.7
66	65.8	5.8
67	66.8	5.8
68	67.7	5.9
Dif.	Dep.	Lat.
	85 Deg.	

Dif.	5 Deg. Lat.	Dep.
69	68.7	6.0
70	69.7	6.1
71	70.7	6.2
72	71.7	6.3
73	72.7	6.4
74	73.7	6.5
75	74.7	6.5
76	75.7	6.6
77	76.7	6.7
78	77.7	6.8
79	78.7	6.9
80	79.7	7.0
81	80.7	7.1
82	81.7	7.1
83	82.7	7.2
84	83.7	7.3
85	84.7	7.4
86	85.7	7.5
87	86.7	7.6
88	87.7	7.7
89	88.7	7.8
90	89.7	7.8
91	90.7	7.9
92	91.6	8.0
93	92.6	8.1
94	93.6	8.2
95	94.6	8.3
96	95.6	8.4
97	96.6	8.4
98	97.6	8.5
99	98.6	8.6
100	99.7	8.7
200	199.2	17.4
300	298.9	26.2
Dif.	Dep.	Lat.
	85 Deg.	

Dist.	6 Deg. Lat.	Dep.
1	1.0	.1
2	2.0	.2
3	3.0	.3
4	4.0	.4
5	5.0	.5
6	6.0	.6
7	7.0	.7
8	8.0	.8
9	8.9	.9
10	9.9	1.0
11	10.9	1.1
12	11.9	1.2
13	12.9	1.4
14	13.9	1.5
15	14.9	1.6
16	15.9	1.7
17	16.9	1.8
18	17.9	1.9
19	18.9	2.0
20	19.9	2.1
21	20.9	2.2
22	21.9	2.3
23	22.9	2.4
24	23.9	2.5
25	24.9	2.6
26	25.9	2.7
27	26.8	2.8
28	27.8	2.9
29	28.8	3.0
30	29.8	3.1
31	30.8	3.2
32	31.8	3.3
33	32.8	3.4
34	33.8	3.5
Dist.	Dep.	Lat.
	84 Deg.	

Dist.	6 Deg. Lat.	Dep.
35	34.8	3.6
36	35.8	3.8
37	36.8	3.9
38	37.8	4.0
39	38.8	4.1
40	39.8	4.2
41	40.8	4.3
42	41.8	4.4
43	42.8	4.5
44	43.8	4.6
45	44.7	4.7
46	45.7	4.8
47	46.7	4.9
48	47.7	5.0
49	48.7	5.1
50	49.7	5.2
51	50.7	5.3
52	51.7	5.4
53	52.7	5.5
54	53.7	5.6
55	54.7	5.7
56	55.7	5.8
57	56.7	5.9
58	57.7	6.1
59	58.7	6.2
60	59.7	6.3
61	60.7	6.4
62	61.7	6.5
63	62.7	6.6
64	63.7	6.7
65	64.6	6.8
66	65.6	6.9
67	66.6	7.0
68	67.6	7.1
Dist.	Dep.	Lat.
	84 Deg.	

Dist.	6 Deg. Lat.	Dep.
69	68.6	7.2
70	69.6	7.3
71	70.6	7.4
72	71.6	7.5
73	72.6	7.6
74	73.6	7.7
75	74.6	7.8
76	75.6	7.9
77	76.6	8.0
78	77.6	8.1
79	78.6	8.2
80	79.6	8.3
81	80.6	8.5
82	81.5	8.6
83	82.5	8.7
84	83.5	8.8
85	84.5	8.9
86	85.5	9.0
87	86.5	9.1
88	87.5	9.2
89	88.5	9.3
90	89.5	9.4
91	90.5	9.5
92	91.5	9.6
93	92.5	9.7
94	93.5	9.8
95	94.5	9.9
96	95.5	10.0
97	96.5	10.1
98	97.5	10.2
99	98.5	10.3
100	99.5	10.4
200	198.9	20.9
300	298.3	31.3
Dist.	Dep.	Lat.
	84 Deg.	

Dist.	7 Deg. Lat.	Dep.
1	1.0	.1
2	2.0	.2
3	3.0	.4
4	4.0	.5
5	5.0	.6
6	6.0	.7
7	6.9	.8
8	7.9	1.0
9	8.9	1.1
10	9.9	1.2
11	10.9	1.3
12	11.9	1.5
13	12.9	1.6
14	13.9	1.7
15	14.9	1.8
16	15.9	2.0
17	16.9	2.1
18	17.9	2.2
19	18.9	2.3
20	19.9	2.4
21	20.8	2.6
22	21.8	2.7
23	22.8	2.8
24	23.8	2.9
25	24.8	3.0
26	25.8	3.2
27	26.8	3.3
28	27.8	3.4
29	28.8	3.5
30	29.8	3.7
31	30.8	3.8
32	31.8	3.9
33	32.7	4.0
34	33.7	4.1
Dist.	Dep.	Lat.

83 Deg.

Dist.	7 Deg. Lat.	Dep.
35	34.7	4.3
36	35.7	4.4
37	36.7	4.5
38	37.7	4.6
39	38.7	4.8
40	39.7	4.9
41	40.7	5.0
42	41.7	5.1
43	42.7	5.2
44	43.7	5.4
45	44.7	5.5
46	45.6	5.6
47	46.6	5.7
48	47.6	5.9
49	48.6	6.0
50	49.6	6.1
51	50.6	6.2
52	51.6	6.3
53	52.6	6.5
54	53.6	6.6
55	54.6	6.7
56	55.6	6.8
57	56.6	6.9
58	57.6	7.1
59	58.6	7.2
60	59.6	7.3
61	60.5	7.4
62	61.5	7.6
63	62.5	7.7
64	63.5	7.8
65	64.5	7.9
66	65.5	8.1
67	66.5	8.2
68	67.5	8.3
Dist.	Dep.	Lat.

83 Deg.

Dist.	7 Deg. Lat.	Dep.
69	68.5	8.4
70	69.5	8.5
71	70.5	8.7
72	71.5	8.8
73	72.5	8.9
74	73.4	9.0
75	74.4	9.2
76	75.4	9.3
77	76.4	9.4
78	77.4	9.5
79	78.4	9.6
80	79.4	9.8
81	80.4	9.9
82	81.4	10.0
83	82.4	10.1
84	83.4	10.3
85	84.4	10.4
86	85.4	10.5
87	86.3	10.6
88	87.3	10.7
89	88.3	10.9
90	89.3	11.0
91	90.3	11.1
92	91.3	11.2
93	92.3	11.3
94	93.3	11.5
95	94.3	11.6
96	95.3	11.7
97	96.3	11.8
98	97.3	12.0
99	98.3	12.1
100	99.3	12.2
200	198.5	24.4
300	297.8	36.6
Dist.	Dep.	Lat.

83 Deg.

Dist.	8 Deg. Lat.	Dep.	Dist.	8 Deg. Lat.	Dep.	Dist.	8 Deg. Lat.	Dep.
1	1.0	.1	35	34.7	4.9	69	68.3	9.6
2	2.0	.3	36	35.7	5.0	70	69.3	9.7
3	3.0	.4	37	36.6	5.1	71	70.3	9.9
4	4.0	.6	38	37.6	5.3	72	71.3	10.0
5	5.0	.7	39	38.6	5.4	73	72.3	10.2
6	5.9	.8	40	39.6	5.6	74	73.3	10.3
7	6.9	1.0	41	40.6	5.7	75	74.3	10.4
8	7.9	1.1	42	41.6	5.8	76	75.3	10 6
9	8.9	1.3	43	42.6	6.0	77	76.3	10.7
10	9.9	1.4	44	43.6	6.1	78	77.2	10.9
11	10.9	1.5	45	44.6	6.3	79	78.2	11.0
12	11.9	1.7	46	45.6	6.4	80	79.2	11.1
13	12.9	1.8	47	46.5	6.5	81	80.2	11.3
14	13.9	1.9	48	47.5	6.7	82	81.2	11.4
15	14.8	2.1	49	48.5	6.8	83	82.2	11.5
16	15.8	2.2	50	49.5	7.0	84	83.2	11.7
17	16.8	2.4	51	50.5	7.1	85	84.2	11.8
18	17.8	2.5	52	51.5	7.2	86	85.2	12 0
19	18.8	2.6	53	52.5	7.4	87	86.2	12.1
20	19.8	2.8	54	53.5	7.5	88	87.2	12.2
21	20.8	2.9	55	54.5	7.7	89	88.1	12.4
22	21.8	3.1	56	55.5	7.8	90	89.1	12.5
23	22.8	3.2	57	56.5	7.9	91	90.1	12.7
24	23.8	3.3	58	57.4	8.1	92	91.1	12.8
25	24.8	3.5	59	58.4	8.2	93	92.1	12.9
26	25.7	3.6	60	59.4	8.3	94	93.1	13.1
27	26.7	3.8	61	60.4	8.5	95	94.1	13.2
28	27.7	3.9	62	61.4	8.6	96	95.1	13.4
29	28.7	4.0	63	62.4	8.8	97	96.1	13.5
30	29.7	4.2	64	63.4	8.9	98	97.0	13.6
31	30.7	4.3	65	64.4	9.0	99	98.0	13.8
32	31.7	4.4	66	65.4	9.2	100	99.0	13.9
33	32.7	4.6	67	66.4	9.3	200	198.1	27.8
34	33.7	4.7	68	67.3	9.5	300	297.1	41.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
	82 Deg.			82 Deg.			82 Deg.	

Dist.	9 Deg. Lat.	Dep.
1	1.0	.2
2	2.0	.3
3	3.0	.5
4	4.0	.6
5	4.9	.8
6	5.9	.9
7	6.9	1.1
8	7.9	1.3
9	8.9	1.4
10	9.9	1.6
11	10.9	1.7
12	11.9	1.9
13	12.9	2.0
14	13.8	2.2
15	14.8	2.3
16	15.8	2.5
17	16.8	2.6
18	17.8	2.8
19	18.8	3.0
20	19.8	3.1
21	20.8	3.3
22	21.7	3.4
23	22.7	3.6
24	23.7	3.7
25	24.7	3.9
26	25.7	4.1
27	26.7	4.2
28	27.7	4.4
29	28.7	4.5
30	29.6	4.7
31	30.6	4 8
32	31.6	5.0
33	32.6	5.1
34	33.6	5.3
Dist.	Dep.	Lat.
	81 Deg.	

Dist.	9 Deg. Lat.	Dep.
35	34.6	5.5
36	35.6	5.6
37	36.6	5.8
38	37.5	5.9
39	38.5	6.1
40	39.5	6.3
41	40.5	6.4
42	41.5	6.6
43	42.5	6.7
44	43.5	6.9
45	44.5	7.0
46	45.4	7.2
47	46.4	7.3
48	47.4	7.5
49	48.4	7.7
50	49.4	7.8
51	50.4	8.0
52	51.4	8.1
53	52.4	8.3
54	53.4	8.4
55	54.3	8.6
56	55.3	8.8
57	56.3	8.9
58	57.3	9.1
59	58.3	9.2
60	59.3	9.4
61	60.3	9.5
62	61.2	9.7
63	62.2	9.8
64	63.2	10.0
65	64.2	10.2
66	65.2	10.3
67	66.2	10.5
68	67.2	10.6
Dist.	Dep.	Lat.
	81 Deg.	

Dist.	9 Deg. Lat.	Dep.
69	68.2	10.8
70	69.1	10.9
71	70.1	11.1
72	71.1	11.2
73	72.1	11.4
74	73.1	11.6
75	74.1	11.7
76	75.1	11.9
77	76.1	12.0
78	77.0	12.2
79	78.0	12.4
80	79.0	12.5
81	80.0	12.7
82	81.0	12.8
83	82.0	13.0
84	83.0	13.1
85	84.0	13.3
86	85.0	13.4
87	85.9	13.6
88	86.9	13.8
89	87.9	13.9
90	88.9	14.1
91	89.9	14.2
92	90.9	14.4
93	91.9	14.5
94	92.9	14.7
95	93.8	14.8
96	94.8	15.0
97	95.8	15.2
98	96.8	15.3
99	97.8	15.5
100	98.8	15.6
200	197.5	31.3
300	296.3	46.9
Dist.	Dep.	Lat.
	81 Deg.	

Dist.	10 Deg. Lat.	Dep.
1	1.0	.2
2	2.0	.3
3	3.0	.5
4	3.9	.7
5	4.9	.9
6	5.9	1.0
7	6.9	1.2
8	7.9	1.4
9	8.9	1.6
10	9.9	1.7
11	10.8	1.9
12	11.8	2.1
13	12.8	2.3
14	13.8	2.4
15	14.8	2.6
16	15.8	2.8
17	16.8	3.0
18	17.7	3.1
19	18.7	3.3
20	19.7	3.5
21	20.7	3.6
22	21.7	3.8
23	22.7	4.0
24	23.6	4.2
25	24.6	4.3
26	25.6	4.5
27	26.6	4.7
28	27.6	4.9
29	28.6	5.0
30	29.6	5.2
31	30.5	5 4
32	31.5	5.5
33	32.5	5.7
34	33.5	5.9
Dist.	Dep.	Lat.
	80 Deg.	

Dist.	10 Deg. Lat.	Dep.
35	34.5	6.1
36	35.5	6.2
37	36.5	6.4
38	37.4	6.6
39	38.4	6.8
40	39.4	6.9
41	40.4	7.1
42	41.4	7.3
43	42.4	7.5
44	43.3	7.6
45	44.3	7.8
46	45.3	8.0
47	46.3	8.1
48	47.3	8.3
49	48.3	8.5
50	49.2	8 7
51	50.2	8.8
52	51.2	9.0
53	52.2	9.2
54	53.2	9.4
55	54.2	9.5
56	55.2	9.7
57	56.1	9.9
58	57.1	10.1
59	58.1	10.2
60	59.1	10.4
61	60.1	10.6
62	61.1	10.8
63	62.0	10.9
64	63.0	11.1
65	64.0	11.3
66	65.0	11.5
67	66.0	11.6
68	67.0	11.8
Dist.	Dep.	Lat.
	80 Deg.	

Dist.	10 Deg. Lat.	Dep.
69	68.0	12.0
70	68.9	12.1
71	69.9	12.3
72	70.9	12.5
73	71.9	12.7
74	72.9	12.8
75	73.9	13.0
76	74.9	13.2
77	75.8	13.3
78	76.8	13.5
79	77.8	13.7
80	78.8	13.9
81	79.8	14.1
82	80.8	14.2
83	81.7	14.4
84	82.7	14.6
85	83.7	14.8
86	84.7	14.9
87	85.7	15.1
88	86.7	15.3
89	87.6	15.4
90	88.6	15.6
91	89.6	15.8
92	90.6	16.0
93	91.6	16.1
94	92.6	16.3
95	93.6	16.5
96	94.6	16.7
97	95.5	16.8
98	96.5	17.0
99	97.5	17.2
100	98.5	17.4
200	197.0	34.7
300	295.4	52.1
Dist.	Dep.	Lat.
	80 Deg.	

Dist.	11 Deg. Lat.	Dep.
1	1.0	.2
2	2.0	.4
3	2.9	.6
4	3.9	.8
5	4.9	.9
6	5.9	1.1
7	6.9	1.3
8	7.8	1.5
9	8.8	1.7
10	9.8	1.9
11	10.8	2.1
12	11.8	2.3
13	12.8	2.5
14	13.7	2.7
15	14.7	2.9
16	15.7	3.0
17	16.7	3.2
18	17.7	3.4
19	18.6	3.6
20	19.6	3.8
21	20.6	4.0
22	21.6	4.2
23	22.6	4.4
24	23.6	4.6
25	24.5	4.8
26	25.5	5.0
27	26.5	5.1
28	27.5	5.3
29	28.5	5.5
30	29.4	5.7
31	30.4	5.9
32	31.4	6.1
33	32.4	6.3
34	33.4	6.5
Dist.	Dep.	Lat.

79 Deg.

Dist.	11 Deg. Lat.	Dep.
35	34.3	6.7
36	35.3	6.9
37	36.3	7.1
38	37.3	7.2
39	38.3	7.4
40	39.3	7.6
41	40.2	7.8
42	41.2	8.0
43	42.2	8.2
44	43.2	8.4
45	44.2	8.6
46	45.2	8.8
47	46.1	9.0
48	47.1	9.2
49	48.1	9.3
50	49.1	9.5
51	50.1	9.7
52	51.0	9.9
53	52.0	10.1
54	53.0	10.3
55	54.0	10.5
56	55.0	10.7
57	55.9	10.9
58	56.9	11.1
59	57.9	11.2
60	58.9	11.4
61	59.9	11.6
62	60.9	11.8
63	61.8	12.0
64	62.8	12.2
65	63.8	12.4
66	64.8	12.6
67	65.8	12.8
68	66.8	13.0
Dist.	Dep.	Lat.

79 Deg.

Dist.	11 Deg. Lat.	Dep.
69	67.7	13.2
70	68.7	13.4
71	69.7	13.5
72	70.7	13.7
73	71.6	13.9
74	72.6	14.1
75	73.6	14.3
76	74.6	14.5
77	75.6	14.7
78	76.5	14.9
79	77.5	15.1
80	78.5	15.3
81	79.5	15.4
82	80.5	15.6
83	81.5	15.8
84	82.4	16.0
85	83.4	16.2
86	84.4	16.4
87	85.4	16.6
88	86.4	16.8
89	87.3	17.0
90	88.3	17.2
91	89.3	17.4
92	90.3	17.6
93	91.3	17.7
94	92.3	17.9
95	93.2	18.1
96	94.2	18.3
97	95.2	18.5
98	96.2	18.7
99	97.2	18.9
100	98.1	19.1
200	196.3	38.2
300	294.4	57.2
Dist.	Dep.	Lat.

79 Deg.

Dist.	12 Deg. Lat.	Dep.
1	1.0	.2
2	2.0	.4
3	2.9	.6
4	3.9	.8
5	4.9	1.0
6	5.9	1.2
7	6.8	1.5
8	7.8	1.7
9	8.8	1.9
10	9.8	2.1
11	10.8	2.3
12	11.7	2.5
13	12.7	2.7
14	13.7	2.9
15	14.7	3.1
16	15.6	3.3
17	16.6	3.6
18	17.6	3.8
19	18.6	4.0
20	19.6	4.2
21	20.5	4.4
22	21.5	4.6
23	22.5	4.8
24	23.5	5.0
25	24.5	5.2
26	25.4	5.4
27	26.4	5.6
28	27.4	5.8
29	28.4	6.0
30	29.3	6.2
31	30.3	6.4
32	31.3	6.6
33	32.3	6.9
34	33.3	7.1
Dist.	Dep.	Lat.
	78 Deg.	

Dist.	12 Deg. Lat.	Dep.
35	34.2	7.3
36	35.2	7.5
37	36.2	7.7
38	37.2	7.9
39	38.1	8.1
40	39.1	8.3
41	40.1	8.5
42	41.1	8.7
43	42.0	9.0
44	43.0	9.2
45	44.0	9.4
46	45.0	9.6
47	46.0	9.8
48	47.0	10.0
49	47.9	10.2
50	48.9	10.4
51	49.9	10.6
52	50.9	10.8
53	51.8	11.0
54	52.8	11.2
55	53.8	11.4
56	54.8	11.6
57	55.8	11.8
58	56.7	12.1
59	57.7	12.3
60	58.7	12.5
61	59.7	12.7
62	60.7	12.9
63	61.6	13.1
64	62.6	13.3
65	63.6	13.5
66	64.6	13.7
67	65.5	14.0
68	66.5	14.2
Dist.	Dep.	Lat.
	78 Deg.	

Dist.	12 Deg. Lat.	Dep.
69	67.5	14.4
70	68.5	14.6
71	69.4	14.8
72	70.4	15.0
73	71.4	15.2
74	72.4	15.4
75	73.4	15.6
76	74.3	15.8
77	75.3	16.0
78	76.3	16.2
79	77.3	16.4
80	78.3	16.6
81	79.2	16.8
82	80.2	17.0
83	81.2	17.3
84	82.2	17.5
85	83.1	17.7
86	84.1	17.9
87	85.1	18.1
88	86.1	18.3
89	87.1	18.5
90	88.0	18.7
91	89.0	18.9
92	90.0	19.1
93	91.0	19.3
94	92.0	19.5
95	92.9	19.7
96	93.9	20.0
97	94.9	20.2
98	95.9	20.4
99	96.8	20.6
100	97.8	20.8
200	195.6	41.6
300	293.4	62.4
Dist.	Dep.	Lat.
	78 Deg.	

Dist.	13 Deg. Lat.	Dep.
1	1.0	.2
2	2.0	.4
3	2.9	.7
4	3.9	.9
5	4.9	1.1
6	5.9	1.3
7	6.8	1.6
8	7.8	1.8
9	8.8	2.0
10	9.8	2.2
11	10.7	2.5
12	11.7	2.7
13	12.7	2.9
14	13.6	3.1
15	14.6	3.4
16	15.6	3.6
17	16.6	3.8
18	17.6	4.0
19	18.5	4.3
20	19.5	4.5
21	20.5	4.7
22	21.5	4.9
23	22.4	5.2
24	23.4	5.4
25	24.4	5.6
26	25.4	5.8
27	26.3	6.1
28	27.3	6.3
29	28.3	6.5
30	29.2	6.7
31	30.2	7.0
32	31.2	7.2
33	32.2	7.4
34	33.1	7.6
Dist.	Dep.	Lat.

77 Deg.

Dist.	13 Deg. Lat.	Dep.
35	34.1	7.9
36	35.1	8.1
37	36.1	8.3
38	37.0	8.6
39	38.0	8.8
40	39.0	9.0
41	40.0	9.2
42	40.9	9.4
43	41.9	9.7
44	42.9	9.9
45	43.8	10.1
46	44.8	10.3
47	45.8	10.6
48	46.8	10.8
49	47.7	11.0
50	48.7	11.2
51	49.7	11.5
52	50.7	11.7
53	51.6	11.9
54	52.6	12.1
55	53.6	12.4
56	54.6	12.6
57	55.5	12.8
58	56.5	13.0
59	57.5	13.3
60	58.5	13.5
61	59.4	13.7
62	60.4	14.0
63	61.4	14.2
64	62.4	14.4
65	63.4	14.6
66	64.3	14.8
67	65.3	15.1
68	66.3	15.3
Dist.	Dep.	Lat.

77 Deg.

Dist.	13 Deg. Lat.	Dep.
69	67.2	15.5
70	68.2	15.7
71	69.2	16.0
72	70.2	16.2
73	71.1	16.4
74	72.1	16.6
75	73.1	16.9
76	74.1	17.1
77	75.0	17.3
78	76.0	17.5
79	77.0	17.8
80	78.0	18.0
81	78.9	18.2
82	79.9	18.4
83	80.9	18.7
84	81.8	18.9
85	82.8	19.1
86	83.8	19.3
87	84.8	19.6
88	85.7	19.8
89	86.7	20.0
90	87.7	20.2
91	88.7	20.5
92	89.6	20.7
93	90.6	20.9
94	91.6	21.1
95	92.6	21.4
96	93.5	21.6
97	94.5	21.8
98	95.5	22.1
99	96.5	22.3
100	97.4	22.5
200	194.9	45.0
300	292.3	67.5
Dist.	Dep.	Lat.

77 Deg.

Dist.	14 Deg. Lat.	Dep.
1	1.0	.2
2	1.9	.5
3	2.9	.7
4	3.9	1.0
5	4.8	1.2
6	5.8	1.4
7	6.8	1.7
8	7.8	1.9
9	8.7	2.2
10	9.7	2.4
11	10.7	2.7
12	11.6	2.9
13	12.6	3.1
14	13.6	3.4
15	14.6	3.6
16	15.5	3.9
17	16.5	4.1
18	17.5	4.4
19	18.4	4.6
20	19.4	4.8
21	20.4	5.1
22	21.3	5.3
23	22.3	5.6
24	23.3	5.8
25	24.2	6.0
26	25.2	6.3
27	26.2	6.5
28	27.2	6.8
29	28.1	7.0
30	29.1	7.3
31	30.1	7.5
32	31.0	7.7
33	32.0	8.0
34	33.0	8.2
Dist.	Dep.	Lat.
	76 Deg.	

Dist.	14 Deg. Lat.	Dep.
35	34.0	8.5
36	34.9	8.7
37	35.9	9.0
38	36.9	9.2
39	37.8	9.4
40	38.8	9.7
41	39.8	9.9
42	40.7	10.2
43	41.7	10.4
44	42.7	10.7
45	43.7	10.9
46	44.6	11.1
47	45.6	11.4
48	46.6	11.6
49	47.5	11.9
50	48.5	12.1
51	49.5	12.3
52	50.4	12.6
53	51.4	12.8
54	52.4	13.1
55	53.4	13.3
56	54.3	13.6
57	55.3	13.8
58	56.3	14.0
59	57.2	14.3
60	58.2	14.5
61	59.2	14.8
62	60.1	15.0
63	61.1	15.3
64	62.1	15.5
65	63.1	15.7
66	64.0	16.0
67	65.0	16.2
68	66.0	16.5
Dist.	Dep.	Lat.
	76 Deg.	

Dist.	14 Deg. Lat.	Dep.
69	66.9	16.7
70	67.9	16.9
71	68.9	17.2
72	69.8	17.4
73	70.8	17.7
74	71.8	17.9
75	72.8	18.2
76	73.7	18.4
77	74.7	18.7
78	75.7	18.9
79	76.6	19.1
80	77.6	19.4
81	78.6	19.5
82	79.6	19.7
83	80.5	20.0
84	81.5	20.2
85	82.5	20.5
86	83.4	20.7
87	84.4	20.9
88	85.4	21.3
89	86.4	21.5
90	87.3	21.8
91	88.3	22.0
92	89.3	22.3
93	90.2	22.5
94	91.2	22.7
95	92.1	23.0
96	93.1	23.2
97	94.1	23.5
98	95.1	23.7
99	96.0	24.0
100	97.0	24.2
200	194.1	48.4
300	291.1	72.6
Dist.	Dep.	Lat.
	76 Deg.	

Dist.	15 Deg. Lat.	Dep.
1	1.0	.3
2	1.9	.5
3	2.9	.8
4	3.9	1.0
5	4.8	1.3
6	5.8	1.6
7	6.8	1.8
8	7.7	2.1
9	8.7	2.3
10	9.7	2.6
11	10.6	2.8
12	11.6	3.1
13	12.6	3.4
14	13.5	3.6
15	14.5	3.9
16	15.5	4.1
17	16.4	4.4
18	17.4	4.7
19	18.3	4.9
20	19.3	5.2
21	20.3	5.4
22	21.3	5.7
23	22.2	6.0
24	23.2	6.2
25	24.2	6.5
26	25.1	6.7
27	26.1	7.0
28	27.1	7.3
29	28.0	7.5
30	29.0	7.8
31	29.9	8.0
32	30.9	8.3
33	31.9	8.5
34	32.8	8.8
Dist.	Dep.	Lat.
	75 Deg.	

Dist.	15 Deg. Lat.	Dep.
35	33.8	9.1
36	34.8	9.3
37	35.7	9.6
38	36.7	9.8
39	37.7	10.1
40	38.6	10.3
41	39.6	10.6
42	40.6	10.9
43	41.5	11.1
44	42.5	11.4
45	43.5	11.6
46	44.4	11.9
47	45.4	12.3
48	46.4	12.5
49	47.3	12.8
50	48.3	12.9
51	49.3	13.2
52	50.2	13.5
53	51.2	13.7
54	52.2	14.0
55	53.1	14.2
56	54.1	14.5
57	55.1	14.8
58	56.0	15.0
59	57.0	15.3
60	58.0	15.5
61	58.9	15.8
62	59.9	16.0
63	60.8	16.3
64	61.8	16.6
65	62.8	16.8
66	63.8	17.1
67	64.7	17.4
68	65.7	17.6
Dist.	Dep.	Lat.
	75 Deg.	

Dist.	15 Deg. Lat.	Dep.
69	66.6	17 9
70	67.6	18.1
71	68.6	18.4
72	69.6	18.6
73	70.5	18.9
74	71.5	19.2
75	72.4	19.4
76	73.4	19.7
77	74.4	20.0
78	75.4	20.2
79	76.3	20.5
80	77.3	20.7
81	78.3	21.0
82	79.2	21.2
83	80.2	21.5
84	81.1	21.7
85	82.1	22.0
86	83.1	22.3
87	84.0	22.5
88	85.0	22.8
89	86.0	23.0
90	86.9	23.3
91	87.9	23.6
92	88.9	23.8
93	89.8	24.1
94	90.8	24.3
95	91.8	24.6
96	92.7	24.8
97	93.7	25.1
98	94.7	25.4
99	95.6	25.6
100	96.6	25.9
200	193.2	51.8
300	289.8	77.6
Dist.	Dep.	Lat.
	75 Deg.	

Dist.	16 Deg. Lat.	Dep.
1	1.0	.3
2	1.9	.6
3	2.9	.8
4	3.8	1.1
5	4.8	1.4
6	5.8	1.7
7	6.7	1.9
8	7.7	2.2
9	8.6	2.5
10	9.6	2.8
11	10.6	3.0
12	11.5	3.3
13	12.5	3.6
14	13.4	3.9
15	14.4	4.1
16	15.4	4.4
17	16.3	4.7
18	17.3	5.0
19	18.3	5.3
20	19.2	5.5
21	20.2	5.8
22	21.1	6.1
23	22.2	6.3
24	23.1	6.6
25	24.0	6.9
26	25.0	7.2
27	25.9	7.5
28	26.9	7.7
29	27.9	8.0
30	28.8	8.3
31	29.8	8.5
32	30.8	8.8
33	31.7	9.1
34	32.7	9.4
Dist.	Dep.	Lat.

74 Deg.

Dist.	16 Deg. Lat.	Dep.
35	33.6	9.7
36	34.6	9.9
37	35.6	10.2
38	36.5	10.5
39	37.5	10.7
40	38.4	11.0
41	39.4	11.3
42	40.4	11.6
43	41.3	11.9
44	42.3	12.1
45	43.2	12.4
46	44.2	12.7
47	45.2	13.0
48	46.1	13.2
49	47.1	13.5
50	48.1	13.8
51	49.0	14.1
52	50.0	14.3
53	50.9	14.6
54	51.9	14.9
55	52.9	15.1
56	53.8	15.4
57	54.8	15.7
58	55.7	16.0
59	56.7	16.3
60	57.7	16.5
61	58.6	16.8
62	59.6	17.1
63	60.6	17.4
64	61.5	17.7
65	62.5	17.9
66	63.4	18.2
67	64.4	18.5
68	65.4	18.8
Dist.	Dep.	Lat.

74 Deg.

Dist.	16 Deg. Lat.	Dep.
69	66.3	19.0
70	67.3	19.3
71	68.2	19.6
72	69.2	19.9
73	70.2	20.1
74	71.1	20.4
75	72.1	20.7
76	73.1	21.0
77	74.0	21.3
78	75.0	21.5
79	75.9	21.8
80	76.9	22.0
81	77.9	22.3
82	78.8	22.6
83	79.8	22.9
84	80.7	23.2
85	81.7	23.5
86	82.7	23.7
87	83.6	24.0
88	84.6	24.3
89	85.6	24.5
90	86.5	24.8
91	87.5	25.1
92	88.4	25.4
93	89.4	25.7
94	90.4	25.9
95	91.3	26.2
96	92.3	26.5
97	93.2	26.7
98	94.2	27.0
99	95.2	27.3
100	96.1	27.6
200	192.3	55.1
300	288.4	82.7
Dist.	Dep.	Lat.

74 Deg.

Dist.	17 Deg. Lat.	Dep.
1	1.0	.3
2	1.9	.6
3	2.9	.9
4	3.8	1.2
5	4.8	1.5
6	5.7	1.7
7	6.7	2.0
8	7.6	2.3
9	8.6	2.6
10	9.6	2.9
11	10.5	3.2
12	11.5	3.5
13	12.4	3.8
14	13.4	4.1
15	14.3	4.4
16	15.3	4.7
17	16.2	5.0
18	17.2	5.2
19	18.2	5.5
20	19.1	5.8
21	20.1	6.1
22	21.0	6.4
23	22.0	6.7
24	23.0	7.0
25	23.9	7.3
26	24.9	7.6
27	25.8	7.9
28	26.8	8.2
29	27.7	8.5
30	28.7	8.8
31	29.6	9.1
32	30.6	9.3
33	31.6	9.6
34	32.5	9.9
Dist.	Dep.	Lat.

73 Deg.

Dist.	17 Deg. Lat.	Dep.
35	33.5	10.2
36	34.4	10.5
37	35.4	10.8
38	36.3	11.1
39	37.3	11.4
40	38.3	11.7
41	39.2	12.0
42	40.2	12.3
43	41.1	12.6
44	42.1	12.9
45	43.0	13.1
46	44.0	13.4
47	44.9	13.7
48	45.9	14.0
49	46.9	14.3
50	47.8	14.6
51	48.8	14.9
52	49.7	15.2
53	50.7	15.5
54	51.6	15.8
55	52.6	16.1
56	53.5	16.4
57	54.5	16.7
58	55.4	17.0
59	56.4	17.2
60	57.4	17.5
61	58.3	17.8
62	59.3	18.1
63	60.2	18.4
64	61.2	18.7
65	62.2	19.0
66	63.1	19.3
67	64.1	19.6
68	65.0	19.9
Dist.	Dep.	Lat.

73 Deg.

Dist.	17 Deg. Lat.	Dep.
69	66.0	20.2
70	66.9	20.5
71	67.9	20.7
72	68.8	21.0
73	69.8	21.3
74	70.8	21.6
75	71.7	21.9
76	72.7	22.2
77	73.6	22.5
78	74.6	22.8
79	75.5	23.1
80	76.5	23.4
81	77.5	23.7
82	78.4	24.0
83	79.4	24.3
84	80.3	24.6
85	81.3	24.8
86	82.2	25.1
87	83.2	25.4
88	84.2	25.7
89	85.1	26.0
90	86.1	26.3
91	87.0	26.6
92	88.0	26.9
93	88.9	27.2
94	89.9	27.5
95	90.8	27.8
96	91.8	28.1
97	92.7	28.4
98	93.7	28.7
99	94.7	28.9
100	95.6	29.2
200	191.3	58.5
300	286.9	87.7
Dist.	Dep.	Lat.

73 Deg.

Dist.	18 Deg. Lat.	Dep.
1	1.0	.3
2	1.9	.6
3	2.8	.9
4	3.8	1.2
5	4.7	1.5
6	5.7	1.8
7	6.6	2.2
8	7.6	2.5
9	8.5	2.8
10	9.5	3.1
11	10.4	3.4
12	11.4	3.7
13	12.3	4.0
14	13.3	4.3
15	14.2	4.6
16	15.2	5.0
17	16.1	5.3
18	17.1	5.6
19	18.0	5.9
20	19.0	6.2
21	20.0	6.5
22	20.9	6.8
23	21.9	7.1
24	22.8	7.4
25	23.8	7.7
26	24.7	8.1
27	25.7	8.4
28	26.6	8.7
29	27.6	9.0
30	28.5	9.3
31	29.5	9.6
32	30.4	9.9
33	31.4	10.2
34	32.3	10.5
Dist.	Dep.	Lat.
	72 Deg.	

Dist.	18 Deg. Lat.	Dep.
35	33.3	10.8
36	34.2	11.1
37	35.2	11.4
38	36.1	11.7
39	37.1	12.0
40	38.0	12.4
41	39.0	12.7
42	39.8	13.0
43	40.8	13.3
44	41.7	13.6
45	42.7	13.9
46	43.6	14.2
47	44.6	14.5
48	45.5	14.8
49	46.5	15.1
50	47.6	15.4
51	48.5	15.8
52	49.5	16.1
53	50.4	16.4
54	51.4	16.7
55	52.3	17.0
56	53.3	17.3
57	54.2	17.6
58	55.2	17.9
59	56.1	18.2
60	57.1	18.5
61	58.0	18.8
62	59.6	19.2
63	59.9	19.5
64	60.9	19.8
65	61.8	20.1
66	62.8	20.4
67	63.7	20.7
68	64.7	21.0
Dist.	Dep.	Lat.
	72 Deg.	

Dist.	18 Deg. Lat.	Dep.
69	65.6	21.3
70	66.6	21.6
71	67.5	21.9
72	68.5	22.2
73	69.4	22.5
74	70.4	22.9
75	71.3	23.2
76	72.3	23.5
77	73.2	23.8
78	74.2	24.1
79	75.1	24.4
80	76.1	24.7
81	77.0	25.0
82	78.0	25.3
83	78.9	25.6
84	79.9	26.0
85	80.8	26.3
86	81.8	26.6
87	82.7	26.9
88	83.7	27.2
89	84.6	27.5
90	85.6	27.8
91	86.5	28.1
92	87.5	28.4
93	88.4	28.7
94	89.4	29.0
95	90.3	29.3
96	91.3	29.7
97	92.2	30.0
98	93.2	30.3
99	94.1	30.6
100	95.1	30.9
200	190.2	61.8
300	285.3	92.7
Dist.	Dep.	Lat.
	72 Deg.	

Dist.	19 Deg. Lat.	Dep.
1	.9	.3
2	1.9	.6
3	2.8	1.0
4	3.8	1.3
5	4.7	1.6
6	5.7	2.0
7	6.6	2.3
8	7.5	2.6
9	8.5	2.9
10	9.4	3.3
11	10.4	3.6
12	11.3	3.9
13	12.3	4.2
14	13.2	4.6
15	14.2	4.9
16	15.1	5.2
17	16.1	5.5
18	17.0	5.9
19	18.0	6.2
20	18.9	6.5
21	19.9	6.8
22	20.8	7.2
23	21.7	7.5
24	22.7	7.8
25	23.6	8.2
26	24.6	8.5
27	25.5	8.8
28	26.5	9.1
29	27.4	9.4
30	28.4	9.8
31	29.3	10.1
32	30.3	10.4
33	31.2	10.7
34	32.1	11.1
Dist.	Dep.	Lat.
	71 Deg.	

Dist.	19 Deg. Lat.	Dep.
35	33.1	11.4
36	34.0	11.7
37	35.0	12.1
38	35.9	12.4
39	36.9	12.7
40	37.8	13.0
41	38.8	13.4
42	39.7	13.7
43	40.7	14.0
44	41.6	14.3
45	42.5	14.7
46	43.5	15.0
47	44.4	15.3
48	45.4	15.6
49	46.3	16.0
50	47.3	16.3
51	48.2	16.6
52	49.2	16.9
53	50.1	17.3
54	51.0	17.6
55	52.0	17.9
56	52.9	18.2
57	53.9	18.6
58	54.8	18.9
59	55.8	19.2
60	56.7	19.5
61	57.7	19.9
62	58.6	20.2
63	59.6	20.5
64	60.5	20.8
65	61.5	21.2
66	62.4	21.5
67	63.4	21.8
68	64.3	22.2
Dist.	Dep.	Lat.
	71 Deg.	

Dist.	19 Deg. Lat.	Dep.
69	65.2	22.5
70	66.2	22.8
71	67.1	23.1
72	68.1	23.4
73	69.0	23.8
74	69.9	24.1
75	70.9	24.4
76	71.8	24.7
77	72.8	25.1
78	73.7	25.4
79	74.7	25.7
80	75.6	26.1
81	76.6	26.4
82	77.5	26.7
83	78.5	27.0
84	79.4	27.4
85	80.4	27.7
86	81.3	28.0
87	82.2	28.3
88	83.2	28.7
89	84.1	29.0
90	85.1	29.3
91	86.0	29.6
92	87.0	30.0
93	87.9	30.3
94	88.9	30.6
95	89.8	30.9
96	90.8	31.3
97	91.7	31.6
98	92.6	31.9
99	93.6	32.2
100	94.5	32.6
200	189.1	65.1
300	283.6	97.7
Dist.	Dep.	Lat.
	71 Deg.	

Dist.	20 Deg. Lat.	Dep.
1	.9	.3
2	1.9	.7
3	2.8	1.0
4	3.8	1.4
5	4.7	1.7
6	5.6	2.0
7	6.6	2.4
8	7.5	2.7
9	8.5	3.1
10	9.4	3.4
11	10.3	3.8
12	11.3	4.1
13	12.2	4.4
14	13.2	4.8
15	14.1	5.1
16	15.0	5.5
17	16.0	5.8
18	16.9	6.1
19	17.9	6.5
20	18.8	6.8
21	19.7	7 2
22	20.7	7.5
23	21.6	7.9
24	22.6	8.2
25	23.5	8.5
26	24.4	8.9
27	25.4	9.2
28	26.3	9.6
29	27.2	10.0
30	28.2	10.3
31	29.1	10.6
32	30.1	10.9
33	31.0	11.3
34	31.9	11.6
Dist.	Dep.	Lat.
	70 Deg.	

Dist.	20 Deg. Lat.	Dep.
35	32.9	12.0
36	33.8	12.3
37	34.8	12.6
38	35.7	13.0
39	36.6	13.3
40	37.6	13.7
41	38.5	14.0
42	39.5	14.4
43	40.4	14.7
44	41.3	15.0
45	42.3	15.4
46	43.2	15.7
47	44.2	16.1
48	45.1	16.4
49	46.0	16.8
50	47.0	17.1
51	47.9	17.4
52	48.9	17.8
53	49.8	18.1
54	50.7	18.5
55	51.7	18.8
56	52.6	19.1
57	53.6	19.5
58	54.5	19.8
59	55.4	20.2
60	56.4	20.5
61	57.3	20.9
62	58.3	21.2
63	59.2	21.5
64	60.1	21.9
65	61.1	22.2
66	62.0	22.6
67	63.0	22.9
68	63.9	23.3
Dist.	Dep.	Lat.
	70 Deg.	

Dist.	20 Deg. Lat.	Dep.
69	64.8	23.6
70	65.8	23.9
71	66.7	24.3
72	67.7	24.6
73	68.6	25.0
74	69.5	25.3
75	71.5	25.6
76	71.4	26.0
77	72.4	26.3
78	73.3	26.7
79	74.2	27.0
80	75.2	27.4
81	76.1	27.7
82	77.1	28.0
83	78.0	28.4
84	78.9	28.7
85	80.0	29.1
86	80.8	29.4
87	81.8	29 8
88	82.7	30.1
89	83.6	30.4
90	84.6	30.8
91	85.5	31.1
92	86.4	31.5
93	87.4	31.8
94	88.3	32.1
95	89.3	32.5
96	90.2	32.8
97	91.2	33.2
98	92.1	33.5
99	93.0	33.9
100	94.0	34.2
200	187.9	68.4
300	281.9	102.6
Dist.	Dep.	Lat.
	70 Deg.	

Dist.	21 Deg. Lat.	Dep.
1	.9	.4
2	1.9	.7
3	2.8	1.1
4	3.7	1.4
5	4.7	1.8
6	5.6	2.1
7	6.5	2.5
8	7.5	2.9
9	8.4	3.2
10	9.3	3.6
11	10.3	3.9
12	11.2	4.3
13	12.1	4.7
14	13.1	5.0
15	14.0	5.4
16	14.9	5.7
17	15.9	6.1
18	16.8	6.4
19	17.7	6.8
20	18.7	7.2
21	19.6	7.5
22	20.5	7.9
23	21.5	8.2
24	22.4	8.6
25	23.3	9.0
26	24.3	9.3
27	25.2	9.7
28	26.1	10.0
29	27.1	10.4
30	28.0	10.7
31	28.9	11.1
32	29.9	11.5
33	30.8	11.8
34	31.7	12.2
Dist.	Dep.	Lat.
	69 Deg.	

Dist.	21 Deg. Lat.	Dep.
35	32.7	12.5
36	33.6	12.9
37	34.5	13.2
38	35.5	13.6
39	36.4	14.0
40	37.3	14.3
41	38.3	14.7
42	39.2	15.0
43	40.1	15.4
44	41.1	15.8
45	42.0	16.1
46	42.9	16.5
47	43.9	16.8
48	44.8	17.2
49	45.7	17.6
50	46.7	17.9
51	47.6	18.3
52	48.5	18.6
53	49.5	19.0
54	50.4	19.3
55	51.3	19.7
56	52.3	20.1
57	53.2	20.4
58	54.1	20.8
59	55.1	21.1
60	56.0	21.5
61	56.9	21.9
62	57.9	22.2
63	58.8	22.6
64	59.8	22.9
65	60.7	23.3
66	61.6	23.6
67	62.6	24.0
68	63.5	24.4
Dist.	Dep.	Lat.
	69 Deg.	

Dist.	21 Deg. Lat.	Dep.
69	64.4	24.7
70	65.3	25.1
71	66.3	25.4
72	67.2	25.8
73	68.1	26.2
74	69.1	26.5
75	70.0	26.9
76	70.9	27.2
77	71.9	27.6
78	72.8	27.9
79	73.7	28.3
80	74.7	28.7
81	75.6	29.0
82	76.6	29.4
83	77.5	29.7
84	78.4	30.1
85	79.4	30.5
86	80.3	30.8
87	81.2	31.2
88	82.2	31.5
89	83.1	31.9
90	84.0	32.3
91	84.9	32.6
92	85.9	33.0
93	86.8	33.3
94	87.7	33.7
95	88.7	34.0
96	89.6	34.4
97	90.5	34.8
98	91.5	35.1
99	92.4	35.5
100	93.4	35.8
200	186.7	71.7
300	280.1	107.5
Dist.	Dep.	Lat.
	69 Deg.	

Dist.	22 Deg. Lat.	Dep.
1	.9	.4
2	1.9	.7
3	2.8	1.1
4	3.7	1.5
5	4.6	1.9
6	5.6	2.2
7	6.5	2.6
8	7.4	3.0
9	8.3	3.4
10	9.3	3.7
11	10.2	4.1
12	11.1	4.5
13	12.0	4.9
14	13.0	5.2
15	13.9	5.6
16	14.8	6.0
17	15.7	6.4
18	16.7	6.7
19	17.6	7.1
20	18.5	7.5
21	19.5	7.9
22	20.4	8.2
23	21.3	8.6
24	22.2	9.0
25	23.2	9.4
26	24.1	9.7
27	25.0	10.1
28	26.0	10.5
29	26.9	10.9
30	27.8	11.2
31	28.7	11.6
32	29.7	12.0
33	30.6	12.4
34	31.5	12.7
Dist.	Dep.	Lat.
	68 Deg.	

Dist.	22 Deg. Lat.	Dep.
35	32.4	13.1
36	33.4	13.5
37	34.3	13.9
38	35.2	14.2
39	36.1	14.6
40	37.1	15.0
41	38.0	15.4
42	38.9	15.7
43	39.9	16.1
44	40.8	16.5
45	41.7	16.9
46	42.6	17.2
47	43.6	17.6
48	44.5	18.0
49	45.4	18.4
50	46.4	18.7
51	47.3	19.1
52	48.2	19.5
53	49.1	19.9
54	50.1	20.2
55	51.0	20.6
56	51.9	21.0
57	52.9	21.4
58	53.8	21.7
59	54.7	22.1
60	55.6	22.5
61	56.6	22.9
62	57.5	23.2
63	58.4	23.6
64	59.4	24.0
65	60.3	24.4
66	61.2	24.7
67	62.1	25.1
68	63.1	25.5
Dist.	Dep.	Lat.
	68 Deg.	

Dist.	22 Deg. Lat.	Dep.
69	64.0	25.9
70	64.9	26.2
71	65.8	26.6
72	66.7	27.0
73	67.7	27.4
74	68.6	27.7
75	69.5	28.1
76	70.5	28.5
77	71.4	28.9
78	72.3	29.2
79	73.3	29.6
80	74.2	30.0
81	75.1	30.4
82	76.0	30.7
83	77.0	31.1
84	77.9	31.5
85	78.8	31.9
86	79.7	32.2
87	80.6	32.6
88	81.6	33.0
89	82.5	33.4
90	83.4	33.7
91	84.4	34.1
92	85.3	34.5
93	86.2	34.9
94	87.1	35.2
95	88.1	35.6
96	89.0	36.0
97	89.9	36.4
98	90.9	36.7
99	91.8	37.1
100	92.7	37.5
200	185.4	74.9
300	278.2	112.4
Dist.	Dep.	Lat.
	68 Deg.	

Dist.	23 Deg. Lat.	Dep.
1	.9	.4
2	1.8	.8
3	2.8	1.2
4	3.7	1.6
5	4.6	1.9
6	5.5	2.3
7	6.4	2.7
8	7.4	3.1
9	8.3	3.5
10	9.2	3.9
11	10.1	4.3
12	11.0	4.7
13	12.0	5.1
14	12.9	5.5
15	13.8	5.9
16	14.7	6.2
17	15.6	6.6
18	16.6	7.0
19	17.5	7.4
20	18.4	7.8
21	19.3	8.2
22	20.2	8.6
23	21.2	9.0
24	22.1	9.4
25	23.0	9.8
26	23.9	10.2
27	24.8	10.5
28	25.8	10.9
29	26.7	11.3
30	27.6	11.7
31	28.5	12.1
32	29.4	12.5
33	30.4	12.9
34	31.3	13.3
Dist.	Dep.	Lat.

67 Deg.

Dist.	23 Deg. Lat.	Dep.
35	32.2	13.7
36	33.1	14.1
37	34.0	14.4
38	35.0	14.8
39	35.9	15.2
40	36.8	15.6
41	37.7	16.0
42	38.6	16.4
43	39.6	16.8
44	40.5	17.2
45	41.4	17.6
46	42.3	18.0
47	43.3	18.4
48	44.2	18.7
49	45.1	19.1
50	46.0	19.5
51	46.9	19.9
52	47.9	20.3
53	48.8	20.7
54	49.7	21.1
55	50.6	21.5
56	51.5	21.9
57	52.4	22.3
58	53.4	22.6
59	54.3	23.0
60	55.2	23.4
61	56.1	23.8
62	57.1	24.2
63	58.0	24.6
64	58.9	25.0
65	59.8	25.4
66	60.8	25.8
67	61.8	26.2
68	62.6	26.6
Dist.	Dep.	Lat.

67 Deg.

Dist.	23 Deg. Lat.	Dep.
69	63.5	26.9
70	64.4	27.3
71	65.3	27.7
72	66.3	28.1
73	67.2	28.5
74	68.1	28.9
75	69.0	29.3
76	69.9	29.7
77	70.9	30.1
78	71.8	30.5
79	72.7	30.8
80	73.6	31.2
81	74.6	31.6
82	75.5	32.0
83	76.4	32.4
84	77.3	32.8
85	78.2	33.2
86	79.2	33.6
87	80.1	34.0
88	81.0	34.4
89	81.9	34.8
90	82.8	35.2
91	83.8	35.6
92	84.7	36.0
93	85.6	36.3
94	86.5	36.7
95	87.4	37.0
96	88.4	37.5
97	89.3	37.9
98	90.2	38.3
99	91.1	38.7
100	92.0	39.1
200	184.1	78.1
300	276.1	117.2
Dist.	Dep.	Lat.

67 Deg

Dist.	24 Deg. Lat.	Dep.
1	.9	.4
2	1.8	.8
3	2.7	1.2
4	3.6	1.6
5	4.6	2.0
6	5.5	2.4
7	6.4	2.8
8	7.3	3.2
9	8.2	3.7
10	9.1	4.1
11	10.0	4.5
12	10.9	4.9
13	11.9	5.3
14	12.8	5.7
15	13.7	6.1
16	14.6	6.5
17	15.5	6.9
18	16.4	7.3
19	17.3	7.7
20	18.3	8.1
21	19.2	8.5
22	20.1	9.0
23	21.0	9.4
24	21.9	9.8
25	22.8	10.2
26	23.7	10.6
27	24.6	11.0
28	25.6	11.3
29	26.5	11.7
30	27.4	12.2
31	28.3	12.6
32	29.2	13.0
33	30.1	13.4
34	31.0	13.8
Dist.	Dep.	Lat.
	66 Deg.	

Dist.	24 Deg. Lat.	Dep.
35	32.0	14.2
36	32.9	14.6
37	33.8	15.1
38	34.7	15.5
39	35.6	15.9
40	36.5	16.3
41	37.4	16.7
42	38.4	17.1
43	39.3	17.5
44	40.2	17.9
45	41.1	18.3
46	42.0	18.7
47	42.9	19.1
48	43.8	19.5
49	44.8	19.9
50	45.7	20 3
51	46.6	20.7
52	47.5	21.1
53	48.4	21.6
54	49.3	22.0
55	50.2	22.4
56	51.1	22.8
57	52.1	23.2
58	53.0	23.6
59	53.9	24.0
60	54.8	24.4
61	55.7	24.8
62	56.6	25.2
63	57.5	25.6
64	58.5	26.0
65	59.4	26.4
66	60.3	26.8
67	61.2	27.2
68	62.1	27.6
Dist.	Dep.	Lat.
	66 Deg.	

Dist.	24 Deg. Lat.	Dep.
69	63.0	28.1
70	63.9	28.5
71	64.8	28.9
72	65.8	29.3
73	66.7	29.7
74	67.6	30.1
75	68.5	30.5
76	69.4	30.9
77	70.3	31.3
78	71.2	31.7
79	72.1	32.1
80	73.1	32.5
81	74.0	32.9
82	74.9	33.3
83	75.8	33.7
84	76.7	34.1
85	77.6	34.5
86	78.5	34.9
87	79.5	35.3
88	80.4	35.7
89	81.3	36.2
90	82.2	36.6
91	83.1	37.0
92	84.0	37.4
93	84.9	37.8
94	85.8	38.2
95	86.8	38.6
96	87.7	39.0
97	88.6	39.5
98	89.5	39.9
99	90.4	40.3
100	91.3	40.7
200	182.7	81.3
300	274.0	122.0
Dist.	Dep.	Lat.
	66 Deg.	

Dist.	25 Deg. Lat.	Dep.
1	.9	.4
2	1.8	.8
3	2.7	1.3
4	3.6	1.7
5	4.5	2.1
6	5.4	2.5
7	6.3	3.0
8	7.2	3.4
9	8.1	3.8
10	9.1	4.2
11	10.0	4.7
12	10.9	5.1
13	11.8	5.5
14	12.7	5.9
15	13.6	6.3
16	14.5	6.8
17	15.4	7.2
18	16.3	7.6
19	17.2	8.0
20	18.1	8.4
21	19.0	8.9
22	19.9	9.3
23	20.8	9.7
24	21.8	10.1
25	22.7	10.6
26	23.6	11.0
27	24.5	11.4
28	25.4	11.8
29	26.3	12.3
30	27.2	12.7
31	28.1	13.1
32	29.0	13.5
33	29.9	14.0
34	30.8	14.4
Dist.	Dep.	Lat.
	65 Deg.	

Dist.	25 Deg. Lat.	Dep.
35	31.7	14.8
36	32.6	15.2
37	33.5	15.6
38	34.4	16.1
39	35.3	16.5
40	36.2	16.9
41	37.2	17.3
42	38.1	17.8
43	39.0	18.2
44	39.9	18.6
45	40.8	19.0
46	41.7	19.5
47	42.6	19.9
48	43.5	20.3
49	44.4	20.7
50	45.3	21.1
51	46.2	21.6
52	47.1	22.0
53	48.0	22.4
54	48.9	22.8
55	49.8	23.2
56	50.7	23.7
57	51.6	24.1
58	52.6	24.5
59	53.5	25.0
60	54.4	25.4
61	55.3	25.8
62	56.2	26.2
63	57.1	26.7
64	58.0	27.1
65	58.9	27.5
66	59.8	27.9
67	60.7	28.3
68	61.6	28.8
Dist.	Dep.	Lat.
	65 Deg.	

Dist.	25 Deg. Lat.	Dep.
69	62.5	29.2
70	63.4	29.6
71	64.3	30.0
72	65.2	30.5
73	66.2	30.9
74	67.1	31.3
75	68.0	31.7
76	68.9	32.1
77	69.8	32.6
78	70.7	33.0
79	71.6	33.4
80	72.5	33.8
81	73.4	34.3
82	74.3	34.7
83	75.2	35.1
84	76.1	35.5
85	77.0	36.0
86	77.9	36.4
87	78.8	36.8
88	79.7	37.2
89	80.7	37.6
90	81.6	38.0
91	82.5	38.4
92	83.4	38.9
93	84.3	39.3
94	85.2	39.7
95	86.1	40.1
96	87.0	40.6
97	87.9	41.0
98	88.8	41.4
99	89.7	41.8
100	90.6	42.3
200	181.3	84.5
300	271.9	126.8
Dist.	Dep.	Lat.
	65 Deg.	

Dist.	26 Deg. Lat.	Dep.	Dist.	26 Deg. Lat.	Dep.	Dist.	26 Deg. Lat.	Dep.
1	.9	.4	35	31.5	15.3	69	62.0	30.2
2	1.8	.9	36	32.4	15.8	70	62.9	30.7
3	2.7	1.3	37	33.3	16.2	71	63.8	31.1
4	3.6	1.8	38	34.2	16.6	72	64.7	31.6
5	4.5	2.2	39	35.1	17.1	73	65.6	32.0
6	5.4	2.6	40	36.0	17.5	74	66.5	32.4
7	6.3	3.1	41	36.8	17.9	75	67.4	32.9
8	7.2	3.5	42	37.8	18.4	76	68.3	33.3
9	8.1	3.9	43	38.6	18.8	77	69.2	33.8
10	9.0	4.4	44	39.5	19.3	78	70.1	34.2
11	9.9	4.8	45	40.4	19.7	79	71.0	34.6
12	10.8	5.3	46	41.3	20.2	80	71.9	35.1
13	11.7	5.7	47	42.2	20.6	81	72.8	35.5
14	12.6	6.1	48	43.1	21.0	82	73.7	35.9
15	13.5	6.6	49	44.0	21.4	83	74.6	36.4
16	14.4	7.0	50	44.9	21.9	84	75.5	36.8
17	15.3	7.4	51	45.8	22.3	85	76.4	37.2
18	16.2	7.9	52	46.7	22.8	86	77.3	37.7
19	17.1	8.3	53	47.6	23.2	87	78.2	38.1
20	18.0	8.8	54	48.5	23.7	88	79.1	38.5
21	18.9	9.2	55	49.4	24.1	89	80.0	39.0
22	19.8	9.6	56	50.3	24.5	90	80.9	39.4
23	20.7	10.1	57	51.2	25.0	91	81.8	39.9
24	21.6	10.5	58	52.1	25.4	92	82.7	40.3
25	22.5	10.9	59	53.0	25.8	93	83.6	40.7
26	23.4	11.4	60	53.9	26.3	94	84.5	41.2
27	24.3	11.8	61	54.8	26.7	95	85.4	41.6
28	25.2	12.3	62	55.7	27.2	96	86.3	42.1
29	26.1	12.7	63	56.6	27.6	97	87.2	42.5
30	27.0	13.1	64	57.5	28.0	98	88.1	42.9
31	27.9	13.6	65	58.4	28.5	99	89.0	43.4
32	28.8	14.0	66	59.3	28.9	100	89.9	43.8
33	29.7	14.4	67	60.2	29.4	200	179.8	87.7
34	30.6	14.9	68	61.1	29.8	300	269.6	131.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
	64 Deg.			64 Deg.			64 Deg.	

Dist.	27 Deg. Lat.	Dep.
1	.9	.5
2	1.8	.9
3	2.7	1.4
4	3.6	1.8
5	4.5	2.3
6	5.3	2.7
7	6.2	3.2
8	7.1	3.6
9	8.0	4.1
10	8.9	4.5
11	9.8	5.0
12	10.7	5.4
13	11.6	5.9
14	12.5	6.3
15	13.4	6.8
16	14.3	7.2
17	15.1	7.7
18	16.0	8.2
19	16.9	8.6
20	17.8	9.1
21	18.7	9.5
22	19.6	10.0
23	20.5	10.4
24	21.4	10.9
25	22.3	11.3
26	23.2	11.8
27	24.1	12.2
28	24.9	12.7
29	25.8	13.2
30	26.7	13.6
31	27.6	14.1
32	28.5	14.5
33	29.4	15.0
34	30.3	15.4
Dist.	Dep.	Lat.
	63 Deg.	

Dist.	27 Deg. Lat.	Dep.
35	31.2	15.9
36	32.1	16.3
37	33.0	16.8
38	33.8	17.2
39	34.7	17.7
40	35.6	18.2
41	36.5	18.6
42	37.4	19.1
43	38.3	19.5
44	39.1	20.0
45	40.1	20.4
46	41.0	20.9
47	41.9	21.3
48	42.8	21.8
49	43.6	22.2
50	44.5	22.7
51	45.4	23.2
52	46.3	23.6
53	47.2	24.1
54	48.1	24.5
55	49.0	25.0
56	49.9	25.4
57	50.8	25.9
58	51.7	26.3
59	52.6	26.8
60	53.5	27.2
61	54.3	27.7
62	55.2	28.2
63	56.1	28.6
64	57.0	29.1
65	57.9	29.5
66	58.8	30.0
67	59.7	30.4
68	60.6	30.9
Dist.	Dep.	Lat.
	63 Deg.	

Dist.	27 Deg. Lat.	Dep.
69	61.5	31.3
70	62.4	31.8
71	63.3	32.2
72	64.1	32.7
73	65.0	33.2
74	65.9	33.6
75	66.8	34.1
76	67.7	34.5
77	68.6	35.0
78	69.5	35.4
79	70.4	35.9
80	71.3	36.3
81	72.2	36.8
82	73.1	37.2
83	73.9	37.7
84	74.8	38.1
85	75.7	38.6
86	76.6	39.0
87	77.5	39.5
88	78.4	40.0
89	79.3	40.4
90	80.2	40.9
91	81.1	41.3
92	82.0	41.8
93	82.9	42.2
94	83.7	42.7
95	84.6	43.1
96	85.5	43.6
97	86.4	44.0
98	87.3	44.5
99	88.2	44.9
100	89.1	45.4
200	178.2	60.9
300	267.3	136.3
Dist.	Dep.	Lat.
	63 Deg.	

Dist.	28 Deg. Lat.	Dep.	Dist.	28 Deg. Lat.	Dep.	Dist.	28 Deg. Lat.	Dep.
1	.9	.5	35	30.9	16.4	69	60.9	32.4
2	1.8	.9	36	31.8	16.9	70	61.8	32.9
3	2.6	1.4	37	32.6	17.4	71	62.7	33.3
4	3.5	1.9	38	33.5	17.8	72	63.6	33.8
5	4.4	2.3	39	34.4	18.3	73	64.4	34.3
6	5.3	2.8	40	35.3	18.8	74	65.3	34.7
7	6.2	3.3	41	36.2	19.2	75	66.2	35.2
8	7.1	3.7	42	37.1	19.7	76	67.1	35.7
9	7.9	4.2	43	38.0	20.2	77	68.0	36.1
10	8.8	4.7	44	38.8	20.7	78	68.9	36.6
11	9.7	5.2	45	39.7	21.1	79	69.7	37.1
12	10.6	5.6	46	40.6	21.6	80	70.6	37.6
13	11.5	6.1	47	41.5	22.1	81	71.5	38.0
14	12.4	6.6	48	42.4	22.5	82	72.4	38.5
15	13.2	7.0	49	43.2	23.0	83	73.3	39.0
16	14.1	7.5	50	44.1	23.5	84	74.2	39.4
17	15.0	8.0	51	45.0	23.9	85	75.0	39.9
18	15.9	8.4	52	45.9	24.4	86	75.9	40.4
19	16.8	8.9	53	46.8	24.9	87	76.8	40.8
20	17.7	9.4	54	47.7	25.4	88	77.7	41.3
21	18.5	9.9	55	48.5	25.8	89	78.6	41.8
22	19.4	10.3	56	49.4	26.3	90	79.5	42.2
23	20.3	10.8	57	50.3	26.8	91	80.3	42.7
24	21.2	11.3	58	51.2	27.2	92	81.2	43.2
25	22.1	11.7	59	52.1	27.7	93	82.1	43.7
26	23.0	12.2	60	53.0	28.2	94	83.0	44.1
27	23.8	12.7	61	53.8	28.6	95	83.9	44.6
28	24.7	13.1	62	54.7	29.1	96	84.8	45.1
29	25.6	13.6	63	55.6	29.6	97	85.6	45.5
30	26.5	14.1	64	56.5	30.0	98	86.5	46.0
31	27.4	14.5	65	57.4	30.5	99	87.4	46.5
32	28.2	15.0	66	58.3	31.0	100	88.3	46.9
33	29.1	15.5	67	59.1	31.5	200	176.6	93.9
34	30.0	16.0	68	60.0	31.9	300	264.9	140.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
	62 Deg.			62 Deg.			62 Deg.	

Dist.	29 Deg. Lat.	Dep.
1	.9	.5
2	1.7	1.0
3	2.6	1.4
4	3.5	1.9
5	4.4	2.4
6	5.2	2.9
7	6.1	3.4
8	7.0	3.9
9	7.9	4.3
10	8.7	4.8
11	9.6	5.3
12	10.5	5.8
13	11.4	6.3
14	12.2	6.8
15	13.1	7.3
16	14.0	7.7
17	14.9	8.2
18	15.7	8.7
19	16.6	9.2
20	17.5	9.7
21	18.4	10.2
22	19.2	10.7
23	20.1	11.1
24	21.0	11.6
25	21.9	12.1
26	22.7	12.6
27	23.6	13.1
28	24.5	13.6
29	25.4	14.1
30	26.2	14.5
31	27.1	15.0
32	28.0	15.5
33	28.9	16.0
34	29.7	16.5
Dist.	Dep.	Lat.
	61 Deg.	

Dist.	29 Deg. Lat.	Dep.
35	30.6	17.0
36	31.5	17.4
37	32.4	17.9
38	33.2	18.4
39	34.1	18.9
40	35.0	19.4
41	35.9	19.9
42	36.7	20.3
43	37.6	20.8
44	38.5	21.3
45	39.4	21.8
46	40.2	22.3
47	41.1	22.8
48	42.0	23.3
49	42.9	23.7
50	43.7	24.2
51	44.6	24.7
52	45.5	25.2
53	46.4	25.7
54	47.2	26.2
55	48.1	26.7
56	49.0	27.1
57	49.9	27.6
58	50.7	28.1
59	51.6	28.6
60	52.5	29.1
61	53.4	29.6
62	54.2	30.1
63	55.1	30.5
64	56.0	31.0
65	56.9	31.5
66	57.7	32.0
67	58.6	32.5
68	59.5	33.0
Dist.	Dep.	Lat.
	61 Deg.	

Dist.	29 Deg. Lat.	Dep.
69	60.4	33.4
70	61.2	33.9
71	62.1	34.4
72	63.0	34.9
73	63.8	35.4
74	64.7	35.9
75	65.6	36.3
76	66.5	36.8
77	67.3	37.3
78	68.2	37.8
79	69.1	38.3
80	70.0	38.8
81	70.8	39.3
82	71.7	39.7
83	72.6	40.2
84	73.5	40.7
85	74.3	41.2
86	75.3	41.7
87	76.1	42.2
88	77.0	42.7
89	77.8	43.1
90	78.7	43.6
91	79.6	44.1
92	80.5	44.6
93	81.3	45.1
94	82.2	45.6
95	83.1	46.1
96	84.0	46.5
97	84.8	47.0
98	85.7	47.5
99	86.6	48.0
100	87.5	48.5
200	174.9	97.0
300	262.4	145.5
Dist.	Dep.	Lat.
	61 Deg.	

Dist.	30 Deg. Lat.	Dep.
1	.9	.5
2	1.7	1.0
3	2.6	1.5
4	3.5	2.0
5	4.3	2.5
6	5.2	3.0
7	6.1	3.5
8	6.9	4.0
9	7.8	4.5
10	8.7	5.0
11	9.5	5.5
12	10.4	6.0
13	11.3	6.5
14	12.1	7.0
15	13.0	7.5
16	13.9	8.0
17	14.7	8.5
18	15.6	9.0
19	16.5	9.5
20	17.3	10.0
21	18.2	10.5
22	19.1	11.0
23	19.9	11.5
24	20.8	12.0
25	21.7	12.5
26	22.5	13.0
27	23.4	13.5
28	24.2	14.0
29	25.1	14.5
30	26.0	15.0
31	26.8	15.5
32	27.7	16.0
33	28.6	16.5
34	29.4	17.0
Dist.	Dep.	Lat.
	60 Deg.	

Dist.	30 Deg. Lat.	Dep.
35	30.3	17.5
36	31.2	18.0
37	32.0	18.5
38	32.9	19.0
39	33.8	19.5
40	34.6	20.0
41	35.5	20.5
42	36.4	21.0
43	37.2	21.5
44	38.1	22.0
45	39.0	22.5
46	39.8	23.0
47	40.7	23.5
48	41.6	24.0
49	42.4	24.5
50	43.3	25.0
51	44.2	25.5
52	45.0	26.0
53	45.9	26.5
54	46.8	27.0
55	47.6	27.5
56	48.5	28.0
57	49.4	28.5
58	50.2	29.0
59	51.1	29.5
60	52.0	30.0
61	52.8	30.5
62	53.7	31.0
63	54.6	31.5
64	55.4	32.0
65	56.3	32.5
66	57.2	33.0
67	58.0	33.5
68	58.9	34.0
Dist.	Dep.	Lat.
	60 Deg.	

Dist.	30 Deg. Lat.	Dep.
69	59.8	34.5
70	60.6	35.0
71	61.5	35.5
72	62.3	36.0
73	63.2	36.5
74	64.1	37.0
75	64.9	37.5
76	65.8	38.0
77	66.7	38.5
78	67.6	39.0
79	68.4	39.5
80	69.3	40.0
81	70.2	40.5
82	71.0	41.0
83	71.9	41.5
84	72.7	42.0
85	73.6	42.5
86	74.5	43.0
87	75.3	43.5
88	76.2	44.0
89	77.1	44.5
90	77.9	45.0
91	78.8	45.5
92	79.7	46.0
93	80.6	46.5
94	81.4	47.0
95	82.3	47.5
96	83.2	48.0
97	84.0	48.5
98	84.9	49.0
99	85.7	49.5
100	86.6	50.0
200	173.2	100.0
300	259.8	150.0
Dist.	Dep.	Lat.
	60 Deg.	

Dist.	31 Deg. Lat.	Dep.
1	.9	.5
2	1.7	1.0
3	2.6	1.5
4	3.4	2.1
5	4.3	2.6
6	5.1	3.1
7	6.0	3.6
8	6.9	4.1
9	7.7	4.6
10	8.6	5.1
11	9.4	5.7
12	10.3	6.2
13	11.1	6.7
14	12.0	7.2
15	12.9	7.7
16	13.7	8.2
17	14.6	8.8
18	15.4	9.3
19	16.3	9.8
20	17.1	10.3
21	18.0	10.8
22	18.9	11.3
23	19.7	11.8
24	20.6	12.4
25	21.4	12.9
26	22.3	13.4
27	23.1	13.9
28	24.0	14.4
29	24.9	14.9
30	25.7	15.4
31	26.6	16.0
32	27.4	16.5
33	28.3	17.0
34	29.2	17.5
Dist.	Dep.	Lat.

59 Deg.

Dist.	31 Deg. Lat.	Dep.
35	30.0	18.0
36	30.9	18.5
37	31.7	19.1
38	32.6	19.6
39	33.4	20.1
40	34.3	20.6
41	35.1	21.1
42	36.0	21.6
43	36.9	22.1
44	37.7	22.7
45	38.6	23.2
46	39.4	23.7
47	40.3	24.2
48	41.1	24.7
49	42.0	25.2
50	42.9	25.7
51	43.7	26.3
52	44.6	26.8
53	45.4	27.3
54	46.3	27.8
55	47.1	28.3
56	48.0	28.8
57	48.9	29.4
58	49.7	29.9
59	50.6	30.4
60	51.4	30.9
61	52.3	31.4
62	53.1	31.9
63	54.0	32.4
64	54.9	33.0
65	55.7	33.5
66	56.6	34.0
67	57.4	34.5
68	58.3	35.0
Dist.	Dep.	Lat.

59 Deg.

Dist.	31 Deg. Lat.	Dep.
69	59.1	35.5
70	60.0	36.0
71	60.9	36.6
72	61.7	37.1
73	62.6	37.6
74	63.4	38.1
75	64.3	38.6
76	65.1	39.1
77	66.0	39.7
78	66.9	40.2
79	67.7	40.7
80	68.6	41.2
81	69.4	41.7
82	70.3	42.2
83	71.1	42.7
84	72.0	43.3
85	72.9	43.8
86	73.7	44.3
87	74.6	44.8
88	75.4	45.3
89	76.3	45.8
90	77.1	46.3
91	78.0	46.9
92	78.9	47.4
93	79.7	47.9
94	80.6	48.4
95	81.4	48.9
96	82.3	49.4
97	83.1	50.0
98	84.0	50.5
99	84.9	51.0
100	85.7	51.5
200	171.4	103.0
300	257.2	154.5
Dist.	Dep.	Lat.

59 Deg.

Dist.	32 Deg. Lat.	Dep.
1	.8	.5
2	1.7	1.1
3	2.5	1.6
4	3.4	2.1
5	4.2	2.6
6	5.1	3.2
7	5.9	3.7
8	6.8	4.2
9	7.6	4.8
10	8.5	5.3
11	9.3	5.8
12	10.2	6.4
13	11.0	6.9
14	11.9	7.4
15	12.7	7.9
16	13.6	8.5
17	14.4	9 0
18	15.3	9.5
19	16.1	10.1
20	17.0	10.6
21	17.8	11.1
22	18.7	11.7
23	19.5	12.2
24	20.4	12.7
25	21.2	13.2
26	22.0	13.8
27	22.9	14.3
28	23.7	14.8
29	24.6	15.3
30	25.4	15.9
31	26.3	16.4
32	27.1	17.0
33	28.0	17.5
34	28.7	18.0
Dist.	Dep.	Lat.

58 Deg.

Dist.	32 Deg. Lat.	Dep.
35	29.7	18.5
36	30.5	19.1
37	31.4	19.6
38	32.2	20.1
39	33.1	20.7
40	33.9	21.2
41	34.8	21.7
42	35.6	22.3
43	36.5	22.8
44	37.3	23.3
45	38.2	23.8
46	39.0	24.4
47	39.8	24.9
48	40.7	25.4
49	41.5	26.0
50	42.4	26.5
51	43.2	27.0
52	44.1	27.5
53	44.9	28.1
54	45.8	28.6
55	46.6	29.1
56	47.5	29.7
57	48.3	30.2
58	49.2	30.7
59	50.0	31.3
60	50.9	31.8
61	51.7	32.3
62	52.6	32.9
63	53.4	33.4
64	54.3	33.9
65	55.1	34.4
66	56.0	35.0
67	56.8	35.5
68	58.7	36.0
Dist.	Dep.	Lat.

58 Deg.

Dist.	32 Deg. Lat.	Dep.
69	58.5	36.6
70	59.4	37.1
71	60.2	37.6
72	61.0	38.1
73	61.9	38.7
74	62.7	39.2
75	63.6	39.7
76	64.4	40.3
77	65.3	40.8
78	66.1	41.3
79	67.0	41.9
80	67.8	42.4
81	68.7	42.9
82	69.5	43.4
83	70.3	44.0
84	71.2	44.5
85	72.1	45.0
86	72.9	45.6
87	73.8	46.1
88	74.6	46.6
89	75.5	47.2
90	76.3	47.7
91	77.2	48.2
92	78.0	48.7
93	78.8	49.3
94	79.7	49.8
95	80.5	50.3
96	81.4	50.9
97	82.2	51.4
98	83.1	51.9
99	83.9	52.4
100	84.8	53.0
200	169.6	106.0
300	254.4	159.0
Dist.	Dep.	Lat.

58 Deg.

Dist.	33 Deg. Lat.	Dep.
1	.8	.5
2	1.7	1.1
3	2.5	1.6
4	3.4	2.2
5	4.2	2.7
6	5.0	3.3
7	5.9	3.8
8	6.7	4.4
9	7.6	4.9
10	8.4	5.4
11	9.2	6.0
12	10.1	6.5
13	10.9	7.1
14	11.7	7.6
15	12.6	8.2
16	13.4	8.7
17	14.3	9.3
18	15.1	9.8
19	15.9	10.4
20	16.8	10.9
21	17.6	11.4
22	18.5	12.0
23	19.3	12.5
24	20.1	13.1
25	21.0	13.6
26	21.8	14.2
27	22.7	14.7
28	23.5	15.3
29	24.3	15.8
30	25.2	16.3
31	26.0	16.9
32	26.9	17.4
33	27.7	18.0
34	28 5	18.5
Dist.	Dep.	Lat.

57 Deg.

Dist.	33 Deg. Lat.	Dep.
35	29.4	19.1
36	30.2	19.6
37	31.1	20.2
38	31.9	20.7
39	32.7	21.2
40	33.5	21.8
41	34.4	22.3
42	35.2	22.9
43	36.1	23.4
44	36.9	24.0
45	37.7	24.5
46	38.6	25.1
47	39.4	25.6
48	40.3	26.2
49	41.1	26.7
50	41.9	27.2
51	42.8	27.8
52	43.6	28.3
53	44.5	28.8
54	45.3	29.4
55	46.1	30.0
56	47.0	30.5
57	47.8	31.0
58	48.7	31.6
59	49.5	32.1
60	50.3	32.7
61	51.2	33.2
62	52.0	33.8
63	52.9	34.3
64	53.7	34.8
65	54.5	35.4
66	55.4	35.5
67	56.2	36.5
68	57.1	37.0
Dist.	Dep.	Lat.

57 Deg.

Dist.	33 Deg. Lat.	Dep.
69	57.9	37.6
70	58.7	38.1
71	59.6	38.6
72	60.4	39.2
73	61.2	39.7
74	62.1	40.3
75	62.9	40.8
76	63.7	41.4
77	64.6	41.9
78	65.4	42.5
79	66.3	43.0
80	67.1	43.6
81	67.9	44.1
82	68.8	44.6
83	69.6	45.2
84	70.5	45.7
85	71.3	46.2
86	72.1	46.8
87	73.0	47.3
88	73.8	47.9
89	74.7	48.4
90	75.5	49.0
91	76.3	49.5
92	77.2	50.1
93	78.0	50.6
94	78.9	51.2
95	79.7	51.7
96	80.5	52.2
97	81.4	52.8
98	82.2	53.3
99	83.1	53.9
100	83.9	54.5
200	167.7	108.9
300	251.6	163.4
Dist.	Dep.	Lat.

57 Deg.

Dist.	34 Deg. Lat.	Dep.
1	.8	.6
2	1.7	1.1
3	2.5	2.7
4	3.3	2.2
5	4.1	2.8
6	5.0	3.4
7	5.8	3.9
8	6.6	4.5
9	7.5	5.0
10	8.3	5.6
11	9.1	6.1
12	9.9	6.7
13	10.8	7.3
14	11.6	7.8
15	12.4	8.4
16	13.3	8.9
17	14.1	9.5
18	14.9	10.1
19	15.8	10.6
20	16.6	11.2
21	17.4	11.7
22	18.2	12.3
23	19.1	12.9
24	19.9	13.4
25	20.7	14.0
26	21.6	14.5
27	22.4	15.1
28	23.2	15.7
29	24.0	16.2
30	24.9	16 8
31	25.7	17.3
32	26.5	17.9
33	27.4	18.4
34	28.2	19.0
Dist.	Dep.	Lat.
	56 Deg.	

Dist.	34 Deg. Lat.	Dep.
35	29.0	19.6
36	29.8	20.1
37	30.7	20.7
38	31.5	21.2
39	32.3	21.8
40	33.2	22.4
41	34.0	22.9
42	34.8	23.5
43	35.6	24.0
44	36.5	24.6
45	37.3	25.1
46	38.1	25.7
47	39.0	26.3
48	39.8	26.8
49	40.6	27.4
50	41.4	28.0
51	42.3	28.5
52	43.1	29.1
53	43.9	29.6
54	44.8	30.2
55	45.6	30.7
56	46.4	31.3
57	47.3	31.9
58	48.1	32.4
59	48.9	33.0
60	49.7	33.5
61	50.6	34.1
62	51.4	34.6
63	52.2	35.2
64	53.0	35.8
65	53.9	36.3
66	54.7	36.9
67	55.5	37.4
68	56.4	38.0
Dist.	Dep.	Lat.
	56 Deg.	

Dist.	34 Deg. Lat.	Dep.
69	57.2	38.6
70	58.0	39.1
71	58.8	39.7
72	59.7	40.3
73	60.5	40.8
74	61.3	41.4
75	62.2	41.9
76	63.0	42.5
77	63.8	43.1
78	64.7	43.6
79	65.5	44.2
80	66.3	44.7
81	67.1	45.3
82	68.0	45.8
83	68.8	46.4
84	69.6	47.0
85	70.5	47.5
86	71.3	48.1
87	72.1	48.6
88	72.9	49.2
89	73.8	49.8
90	74.6	50.3
91	75.4	50.9
92	76.3	51.4
93	77.1	52.0
94	77.9	52.6
95	78.8	53.1
96	79.6	53.7
97	80.4	54.2
98	81.2	54.8
99	82.1	55.4
100	82.9	55.9
200	165.8	111.8
300	248.7	167.8
Dist.	Dep.	Lat.
	56 Deg.	

Dist.	35 Deg. Lat.	Dep.
1	.8	.6
2	1.7	1.1
3	2.5	1.7
4	3.3	2.3
5	4.1	2.9
6	4.9	3.4
7	5.7	4.0
8	6.6	4.6
9	7.4	5.2
10	8.2	5.7
11	9.0	6.3
12	9.8	6.9
13	10.6	7.5
14	11.5	8.0
15	12.3	8.6
16	13.1	9.2
17	13.9	9.8
18	14.7	10.3
19	15.6	10.9
20	16.4	11.5
21	17.2	12.0
22	18.0	12.6
23	18.8	13.2
24	19.6	13.8
25	20.5	14.3
26	21.3	14.9
27	22.1	15.5
28	22.9	16.1
29	23.7	16.6
30	24.6	17.2
31	25.4	17.8
32	26.2	18.4
33	27.0	18.9
34	27.8	19.5
Dist.	Dep.	Lat.

55 Deg.

Dist.	35 Deg. Lat.	Dep.
35	28.6	20.1
36	29.5	20.6
37	30.3	21.2
38	31.1	21.8
39	31.9	22.4
40	32.8	22.9
41	33.6	23.5
42	34.4	24.1
43	35.2	24.6
44	36.0	25.2
45	36.8	25.8
46	37.7	26.4
47	38.5	27.0
48	39.3	27.5
49	40.1	28.1
50	41.0	28.7
51	41.8	29.2
52	42.6	29.8
53	43.4	30.4
54	44.2	31.0
55	45.1	31.5
56	45.9	32.1
57	46.7	32.7
58	47.5	33.3
59	48.3	33.8
60	49.1	34.4
61	50.0	35.0
62	50.8	35.6
63	51.6	36.1
64	52.4	36.7
65	53.3	37.3
66	54.1	37.9
67	54.9	38.4
68	55.7	39.0
Dist.	Dep.	Lat.

55 Deg.

Dist.	35 Deg. Lat.	Dep.
69	56.5	39.6
70	57.3	40.2
71	58.2	40.7
72	59.0	41.3
73	59.8	41.9
74	60.6	42.5
75	61.5	43.0
76	62.3	43.6
77	63.1	44.2
78	63.9	44.8
79	64.7	45.3
80	65.5	45.9
81	66.4	46.5
82	67.2	47.0
83	68.0	47.6
84	68.8	48.2
85	69.6	48.8
86	70.5	49.3
87	71.3	49.9
88	72.1	50.5
89	72.9	51.1
90	73.7	51.6
91	74.6	52.2
92	75.4	52.8
93	76.2	53.4
94	77.0	53.9
95	77.8	54.5
96	78.6	55.1
97	79.5	55.6
98	80.3	56.2
99	81.1	56.8
100	81.9	57.4
200	163.8	114.7
300	245.8	172.1
Dist.	Dep.	Lat.

55 Deg.

Dist.	36 Deg. Lat.	Dep.
1	.8	.6
2	1.6	1.2
3	2.4	1.8
4	3.2	2.3
5	4.0	2.9
6	4.8	3.5
7	5.7	4.1
8	6.5	4.7
9	7.2	5.3
10	8.1	5.9
11	8.9	6.5
12	9.7	7.0
13	10.5	7.6
14	11.3	8.2
15	12.1	8.8
16	12.9	9.4
17	13.8	10.0
18	14.6	10.6
19	15.4	11.2
20	16.2	11.8
21	17.0	12.3
22	17.8	12.9
23	18.6	13.5
24	19.4	14.1
25	20.2	14.7
26	21.0	15.3
27	21.8	15.9
28	22.6	16.4
29	23.5	17.0
30	24.3	17.6
31	25.1	18.2
32	25.9	18.8
33	26.7	19.4
34	27.5	20.0
Dist.	Dep.	Lat.

54 Deg.

Dist.	36 Deg. Lat.	Dep.
35	28.3	20.6
36	29.1	21.1
37	29.9	21.7
38	30.7	22.3
39	31.5	22.9
40	32.4	23.5
41	33.2	24.1
42	34.0	24.7
43	34.8	25.3
44	35.6	25.8
45	36.4	26.4
46	37.2	27.0
47	38.0	27.6
48	38.8	28.2
49	39.6	28.8
50	40.4	29.4
51	41.3	30.0
52	42.1	30.6
53	42.9	31.1
54	43.7	31.7
55	44.5	32.3
56	45.3	32.9
57	46.1	33.5
58	46.9	34.1
59	47.7	34.7
60	48.5	35.3
61	49.3	35.8
62	50.2	36.4
63	51.0	37.0
64	51.8	37.6
65	52.6	38.2
66	53.4	38.8
67	54.2	39.4
68	55.0	40.0
Dist.	Dep.	Lat.

54 Deg.

Dist.	36 Deg. Lat.	Dep.
69	55.8	40.6
70	56.6	41.1
71	57.4	41.7
72	58.2	42.3
73	59.0	42.9
74	59.9	43.5
75	60.7	44.1
76	61.5	44.7
77	62.3	45.3
78	63.1	45.8
79	63.9	46.4
80	64.7	47.0
81	65.5	47.6
82	66.3	48.2
83	67.1	48.8
84	68.0	49.4
85	68.8	50.0
86	69.6	50.6
87	70.4	51.1
88	71.2	51.7
89	72.0	52.3
90	72.8	52.9
91	73.6	53.5
92	74.4	54.1
93	75.2	54.7
94	76.0	55.3
95	76.8	55.8
96	77.7	56.4
97	78.5	57.0
98	79.3	57.6
99	80.1	58.2
100	80.9	58.8
200	161.8	117.6
300	242.7	176.3
Dist.	Dep.	Lat.

54 Deg.

Dist.	37 Deg. Lat.	Dep.
1	.8	.6
2	1.6	1.2
3	2.4	1.8
4	3.2	2.4
5	4.0	3.0
6	4.8	3.6
7	5.6	4.2
8	6.4	4.8
9	7.2	5.4
10	8.0	6.0
11	8.8	6.6
12	9.6	7.2
13	10.4	7.8
14	11.2	8.4
15	12.0	9.0
16	12.8	9.6
17	13.6	10.2
18	14.4	10.8
19	15.2	11.4
20	16.0	12.0
21	16.8	12.6
22	17.6	13.2
23	18.4	13.8
24	19.2	14.4
25	20.0	15.0
26	20.8	15.6
27	21.6	16.2
28	22.4	16.8
29	23.2	17.4
30	24.0	18.0
31	24.8	18.6
32	25.6	19.2
33	26.4	19.8
34	27.1	20.4
Dist.	Dep.	Lat.

53 Deg.

Dist.	37 Deg. Lat.	Dep.
35	27.9	21.0
36	28.7	21.6
37	29.5	22.2
38	30.3	22.8
39	31.1	23.4
40	31.9	24.1
41	32.7	24.7
42	33.5	25.3
43	34.3	25.9
44	35.1	26.5
45	35.9	27.1
46	36.7	27.7
47	37.5	28.3
48	38.3	28.9
49	39.1	29.5
50	39.9	30.1
51	40.7	30.7
52	41.5	31.3
53	42.3	31.9
54	43.1	32.5
55	43.9	33.1
56	44.7	33.7
57	45.5	34.3
58	46.3	34.9
59	47.1	35.5
60	47.9	36.1
61	48.7	36.7
62	49.5	37.3
63	50.3	37.9
64	51.1	38.5
65	51.9	39.1
66	52.7	39.7
67	53.5	40.3
68	54.3	40.9
Dist.	Dep.	Lat.

53 Deg.

Dist.	37 Deg. Lat.	Dep.
69	55.1	41.5
70	55.9	42.1
71	56.7	42.7
72	57.5	43.3
73	58.3	43.9
74	59.1	44.5
75	59.9	45.1
76	60.7	45.7
77	61.5	46.3
78	62.3	46.9
79	63.1	47.5
80	63.9	48.1
81	64.7	48.7
82	65.5	49.3
83	66.3	50.0
84	67.1	50.6
85	67.9	51.2
86	68.7	51.8
87	69.5	52.4
88	70.3	53.0
89	71.1	53.6
90	71.9	54.2
91	72.7	54.8
92	73.5	55.4
93	74.3	56.0
94	75.1	56.6
95	75.9	57.2
96	76.7	57.8
97	77.5	58.4
98	78.3	59.0
99	79.1	59.6
100	79.9	60.2
200	159.7	120.4
300	239.6	180.5
Dist.	Dep.	Lat.

53 Deg.

Dist.	38 Deg. Lat.	Dep.
1	.8	.6
2	1.6	1.2
3	2.4	1.8
4	3.1	2.5
5	3.9	3.1
6	4.7	3.7
7	5.5	4.3
8	6.3	4.9
9	7.1	5.5
10	7.9	6.2
11	8.7	6.8
12	9.5	7.4
13	10.2	8.0
14	11.0	8.6
15	11.8	9.2
16	12.6	9.9
17	13.4	10.5
18	14.2	11.1
19	15.0	11.7
20	15.8	12.3
21	16.6	12.9
22	17.3	13.6
23	18.1	14.2
24	18.9	14.8
25	19.7	15.4
26	20.5	16.0
27	21.3	16.6
28	22.1	17.2
29	22.9	17.9
30	23.6	18.5
31	24.4	19.1
32	25.2	19.7
33	26.0	20.3
34	26.8	20.9
Dist.	Dep.	Lat.

52 Deg.

Dist.	38 Deg. Lat.	Dep.
35	27.6	21.6
36	28.4	22.2
37	29.2	22.8
38	29.9	23.4
39	30.7	24.0
40	31.5	24.6
41	32.3	25.2
42	33.1	25.9
43	33.9	26.5
44	34.7	27.1
45	35.5	27.7
46	36.2	28.3
47	37.0	28.9
48	37.8	29.6
49	38.6	30.2
50	39.4	30.8
51	40.2	31.4
52	41.0	32.0
53	41.8	32.6
54	42.6	33.2
55	43.3	33.9
56	44.1	34.5
57	44.9	35.1
58	45.7	35.7
59	46.5	36.3
60	47.3	36.9
61	48.1	37.6
62	48.9	38.2
63	49.6	38.8
64	50.4	39.4
65	51.2	40.0
66	52.0	40.6
67	52.8	41.2
68	53.6	41.9
Dist.	Dep.	Lat.

52 Deg.

Dist.	38 Deg. Lat.	Dep.
69	54.4	42.5
70	55.2	43.1
71	55.9	43.7
72	56.7	44.3
73	57.5	45.0
74	58.3	45.6
75	59.1	46.2
76	59.9	46.8
77	60.7	47.4
78	61.5	48.0
79	62.2	48.6
80	63.3	49.0
81	63.8	49.9
82	64.6	50.5
83	65.4	51.1
84	66.2	51.7
85	67.0	52.3
86	67.8	53.0
87	68.6	53.6
88	69.3	54.2
89	70.1	54.8
90	70.9	55.4
91	71.7	56.0
92	72.5	56.6
93	73.3	57.3
94	74.1	57.9
95	74.9	58.5
96	75.6	59.1
97	76.4	59.7
98	77.2	60.3
99	78.0	61.0
100	78.8	61.6
200	157.6	123.1
300	236.4	184.7
Dist.	Dep.	Lat.

52 Deg.

Dist.	39 Deg. Lat.	Dep.
1	.8	.6
2	1.6	1.3
3	2.3	1.9
4	3.1	2.5
5	3.9	3.1
6	4.7	3.8
7	5.4	4.4
8	6.2	5.0
9	7.0	5.7
10	7.8	6.3
11	8.5	6.9
12	9.3	7.5
13	10.1	8.2
14	10.9	8.8
15	11.6	9.4
16	12.4	10.1
17	13.2	10.7
18	14.0	11.3
19	14.8	11.9
20	15.5	12.6
21	16.3	13.2
22	17.1	13.8
23	17.9	14.5
24	18.6	15.1
25	19.4	15.7
26	20.2	16.4
27	21.0	17.0
28	21.7	17.6
29	22.5	18.2
30	23.3	18.9
31	24.1	19 5
32	24.9	20.1
33	25.6	20.8
34	26.4	21.4
Dist.	Dep.	Lat.
	51 Deg.	

Dist.	39 Deg. Lat.	Dep.
35	27.2	22.0
36	28.0	22.6
37	28.7	23.3
38	29.5	23.9
39	30.3	24.5
40	31.1	25.2
41	31.8	25.8
42	32.6	26.4
43	33.4	27.1
44	34.2	27.7
45	35.0	28.3
46	35.7	28.9
47	36.5	29.6
48	37.3	30.2
49	38.1	30.8
50	38.8	31.5
51	39.6	32.1
52	40.4	32.7
53	41.2	33 4
54	41.9	34.0
55	42.7	34.6
56	43.5	35.2
57	44.3	35.9
58	45.1	36.5
59	45.8	37.1
60	46.6	37.8
61	47.4	38.4
62	48.2	39.0
63	48.9	39.6
64	49.7	40.3
65	50.5	40.9
66	51.3	41.5
67	52.1	42.2
68	52.8	42.8
Dist.	Dep.	Lat.
	51 Deg.	

Dist.	39 Deg. Lat.	Dep.
69	53.6	43.4
70	54.4	44.0
71	55.2	44.7
72	55.9	45.3
73	56.7	45.9
74	57.5	46.6
75	58.3	47.2
76	59.1	47.8
77	59.8	48.5
78	60.6	49.1
79	61.4	49.7
80	62.2	50.3
81	62.9	51.0
82	63.7	51.6
83	64.5	52.2
84	65.3	52.9
85	66.1	53.5
86	66.8	54.1
87	67.6	54.7
88	68.4	55.4
89	69.2	56.0
90	69.9	56.6
91	70.7	57.3
92	71.5	57.9
93	72.3	58.5
94	73.1	59.1
95	73.8	59.8
96	74.6	60.4
97	75.4	61.0
98	76.2	61.7
99	76.9	62.3
100	77.7	62.9
200	155.4	125.9
300	233.1	188.8
Dist.	Dep.	Lat.
	51 Deg.	

Dist.	40 Deg. Lat.	Dep.
1	.8	.6
2	1.5	1.3
3	2.3	1.9
4	3.1	2.6
5	3.8	3.2
6	4.6	3.8
7	5.4	4.5
8	6.1	5.1
9	6.9	5.8
10	7.7	6.4
11	8.4	7.1
12	9.2	7.7
13	10.0	8.3
14	10.7	9.0
15	11.5	9.6
16	12.3	10.3
17	13.0	10.9
18	13.8	11.6
19	14.6	12.2
20	15.3	12.9
21	16.1	13.5
22	16.9	14.1
23	17.6	14.8
24	18.4	15.4
25	19.2	16.1
26	19.9	16.7
27	20.7	17.3
28	21.4	18.0
29	22.2	18.6
30	23.0	19.3
31	23.7	19.9
32	24.5	20.6
33	25.3	21.2
34	26.0	21.9
Dist.	Dep.	Lat.
	50 Deg.	

Dist.	40 Deg. Lat.	Dep.
35	26.8	22.5
36	27.6	23.1
37	28.3	23.8
38	29.1	24.4
39	29.9	25.1
40	30.6	25.7
41	31.4	26.3
42	32.2	27.0
43	32.9	27.6
44	33.7	28.3
45	34.5	28.9
46	35.2	29.6
47	36.0	30.2
48	36.8	30.9
49	37.5	31.5
50	38.3	32.1
51	39.1	32.8
52	39.8	33.4
53	40.6	34.1
54	41.4	34.7
55	42.1	35.3
56	42.9	36.0
57	43.7	36.6
58	44.4	37.3
59	45.2	37.9
60	46.0	38.6
61	46.7	39.2
62	47.5	39.9
63	48.3	40.5
64	49.0	41.1
65	49.8	41.8
66	50.6	42.4
67	51.3	43.1
68	52.1	43.7
Dist.	Dep.	Lat.
	50 Deg.	

Dist.	40 Deg. Lat.	Dep.
69	52.9	44.3
70	53 6	45.0
71	54.4	45.6
72	55.2	46.3
73	55.9	46.9
74	56.7	47.6
75	57.4	48.2
76	58.2	48.5
77	59.0	49.5
78	59.7	50.1
79	60.5	50.8
80	61.3	51.4
81	62.0	52.1
82	62.8	52.7
83	63.6	53.3
84	64.3	54.0
85	65.1	54.6
86	65.9	55.3
87	66.6	55.9
88	67.4	56.6
89	68.2	57.2
90	68.9	57.9
91	69.7	58.5
92	70.5	59.1
93	71.2	59.8
94	72.0	60.4
95	72.7	61.1
96	73.5	61.7
97	74.3	62.3
98	75.1	63.0
99	75.8	63.6
100	76.6	64.3
200	153.2	128.6
300	229.8	192.8
Dist.	Dep.	Lat.
	50 Deg.	

Dist.	41 Deg. Lat.	Dep.
1	.8	.7
2	1.5	1.3
3	2.3	2.0
4	3.0	2.6
5	3.8	3.3
6	4.5	3.9
7	5.3	4.6
8	6.0	5.2
9	6.8	5.9
10	7.5	6.6
11	8.3	7.2
12	9.1	7.9
13	9.8	8.5
14	10.6	9.2
15	11.3	9.8
16	12.1	10.5
17	12.8	11.2
18	13.6	11.8
19	14.3	12.5
20	15.1	13.1
21	15.9	13.8
22	16.6	14.4
23	17.4	15.1
24	18.1	15.7
25	18.9	16.4
26	19.6	17.1
27	20.4	17.7
28	21.1	18.4
29	21.9	19.0
30	22.6	19.7
31	23.4	20.3
32	24.1	21.0
33	24.9	21.6
34	25.7	22.3
Dist.	Dep.	Lat.
	49 Deg.	

Dist.	41 Deg. Lat.	Dep.
35	26.4	22.9
36	27.2	23.6
37	27.9	24.3
38	28.7	24.9
39	29.4	25.6
40	30.2	26.2
41	30.9	26.9
42	31.7	27.5
43	32.4	28.2
44	33.2	28.9
45	33.9	29.5
46	34.7	30.2
47	35.4	30.8
48	36.2	31.5
49	36.9	32.1
50	37.7	32.8
51	38.5	33.4
52	39.2	34.1
53	40.0	34.8
54	40.7	35.4
55	41.5	36.1
56	42.2	36.7
57	43.0	37.4
58	43.8	38.0
59	44.5	38.7
60	45.3	39.4
61	46.0	40.0
62	46.8	40.7
63	47.5	41.3
64	48.3	42.0
65	49.0	42.6
66	49.8	43.3
67	50.6	43.9
68	51.3	44.6
Dist.	Dep.	Lat.
	49 Deg.	

Dist.	41 Deg. Lat.	Dep.
69	52.1	45.2
70	52.8	45.9
71	53.6	46.6
72	54.3	47.2
73	55.1	47.8
74	55.8	48.5
75	56.6	49.2
76	57.4	49.8
77	58.1	50.5
78	58.9	51.2
79	59.6	51.8
80	60.4	52.5
81	61.1	53.1
82	61.9	53.8
83	62.6	54.4
84	63.4	55.1
85	64.1	55.7
86	64.9	56.4
87	65.6	57.1
88	66.4	57.7
89	67.1	58.4
90	67.9	59.0
91	68.7	59.7
92	69.4	60.3
93	70.2	61.0
94	70.9	61.6
95	71.7	62.3
96	72.4	62.9
97	73.2	63.6
98	73.9	64.3
99	74.7	64.9
100	75.5	65.6
200	150.9	131.2
300	226.4	196.8
Dist.	Dep.	Lat.
	49 Deg.	

Dist.	42 Deg. Lat.	Dep.
1	0.7	.7
2	1.5	1.3
3	2.2	2.0
4	3.0	2.7
5	3.7	3.3
6	4.4	4.0
7	5.2	4.7
8	5.9	5.3
9	6.7	6.0
10	7.4	6.7
11	8.2	7.3
12	8.9	8.0
13	9.7	8.7
14	10.4	9.3
15	11.1	10.0
16	11.9	10.7
17	12.6	11.3
18	13.4	12.0
19	14.1	12.7
20	14.9	13.4
21	15.6	14.0
22	16.3	14.7
23	17.1	15.4
24	17.8	16.0
25	18.6	16.7
26	19.3	17.4
27	20.1	18.0
28	20.8	18.7
29	21.5	19.4
30	22.3	20.1
31	23.0	20.7
32	23.8	21.4
33	24.5	22.1
34	25.3	22.7
Dist.	Dep.	Lat.
	48 Deg.	

Dist.	42 Deg. Lat.	Dep.
35	26.0	23.4
36	26.7	24.1
37	27.5	24.7
38	28.2	25.4
39	29.0	26.1
40	29.7	26.8
41	30.4	27.4
42	31.2	28.1
43	31.9	28.7
44	32.7	29.4
45	33.4	30.1
46	34.2	30.8
47	34.9	31.4
48	35.7	32.1
49	36.4	32.8
50	37.2	33.5
51	37.9	34.1
52	38.6	34.8
53	39.4	35.4
54	40.1	36.1
55	40.9	36.8
56	41.6	37.5
57	42.3	38.1
58	43.1	38.8
59	43.8	39.4
60	44.6	40.1
61	45.3	40.8
62	46.1	41.5
63	46.8	42.1
64	47.5	42.8
65	48.3	43.5
66	49.0	44.2
67	49.8	44.8
68	50.5	45.5
Dist.	Dep.	Lat.
	48 Deg.	

Dist.	42 Deg. Lat.	Dep.
69	51.3	46.2
70	52.0	46.8
71	52.7	47.5
72	53.5	48.2
73	54.2	48.8
74	55.0	49.5
75	55.7	50.2
76	56.4	50.9
77	57.2	51.5
78	57.9	52.2
79	58.7	52.9
80	59.4	53.5
81	60.2	54.2
82	60.9	54.9
83	61.7	55.5
84	62.4	56.2
85	63.2	56.9
86	63.9	57.5
87	64.7	58.2
88	65.4	58.9
89	66.1	59.5
90	66.9	60.2
91	67.6	60.9
92	68.4	61.5
93	69.1	62.2
94	69.9	62.9
95	70.6	63.5
96	71.3	64.2
97	72.1	64.9
98	72.8	65.5
99	73.6	66.2
100	74.3	66.9
200	148.6	133.8
300	222.9	200.7
Dist.	Dep.	Lat.
	48 Deg.	

Dist.	43 Deg. Lat.	Dep.
1	.7	.7
2	1.5	1.4
3	2.2	2.0
4	2.9	2.7
5	3.6	3.4
6	4.4	4.1
7	5.1	4.8
8	5.8	5.4
9	6.6	6.1
10	7.3	6.8
11	8.0	7.5
12	8.8	8.2
13	9.5	8.9
14	10.2	9.5
15	11.0	10.2
16	11.7	10.9
17	12.4	11.6
18	13.2	12.3
19	13.9	13.0
20	14.6	13.6
21	15.3	14.3
22	16.1	15.0
23	16.8	15.7
24	17.5	16.4
25	18.3	17.0
26	18.0	17.7
27	19.7	18.4
28	20.5	19.1
29	21.2	19.8
30	21.9	20.5
31	22.7	21.1
32	23.4	21.8
33	24.1	22.5
34	24.8	23.2
Dist.	Dep.	Lat.
	47 Deg.	

Dist.	43 Deg. Lat.	Dep.
35	25.6	23.9
36	26.3	24.5
37	27.0	25.2
38	27.8	25.9
39	28.5	26.6
40	29.2	27.3
41	30.0	28.0
42	30.7	28.6
43	31.4	29.3
44	32.2	30.0
45	32.9	30.7
46	33.6	31.4
47	34.4	32.0
48	35.1	32.7
49	35.8	33.4
50	36.6	34.1
51	37.3	34.8
52	38.0	35.5
53	38.8	36.1
54	39.5	36.8
55	40.2	37.5
56	40.9	38.2
57	41.7	38.9
58	42.4	39.5
59	43.1	40.2
60	43.9	40.9
61	44.6	41.6
62	45.3	42.3
63	46.1	43.0
64	46.8	43.6
65	47.5	44.3
66	48.3	45.0
67	49.0	45.7
68	49.7	46.4
Dist.	Dep.	Lat.
	47 Deg.	

Dist.	43 Deg. Lat.	Dep.
69	50.5	47.0
70	51.2	47.7
71	51.9	48.4
72	52.6	49.1
73	53.4	49.8
74	54.1	50.5
75	54.8	51.1
76	55.6	51.8
77	56.3	52.5
78	57.0	53.2
79	57.8	53.9
80	58.5	54.5
81	59.2	55.2
82	60.0	55.9
83	60.7	56.6
84	61.4	57.3
85	62.2	58.0
86	62.9	58.7
87	63.6	59.3
88	64.3	60.0
89	65.1	60.7
90	65.8	61.4
91	66.5	62.1
92	67.3	62.7
93	68.0	63.4
94	68.7	64.1
95	69.5	64.8
96	70.2	65.5
97	70.9	66.1
98	71.7	66.8
99	72.4	67.5
100	73.1	68.2
200	146.3	136.4
300	219.4	204.6
Dist.	Dep.	Lat
	47 Deg.	

Dist.	44 Deg. Lat.	Dep.
1	.7	.7
2	1.4	1.4
3	2.2	2.1
4	2.9	2.8
5	3.6	3.5
6	4.3	4.2
7	5.0	4.9
8	5.8	5.6
9	6.5	6.2
10	7.2	6.9
11	7.9	7.6
12	8.6	8.3
13	9.3	9.0
14	10.1	9.7
15	10.8	10.4
16	11.5	11.1
17	12.2	11.8
18	12.9	12.5
19	13.7	13.2
20	14.4	13.9
21	15.1	14.6
22	15.8	15.3
23	16.5	16.0
24	17.3	16.7
25	18.0	17.4
26	18.7	18.1
27	19.4	18.8
28	20.1	19.5
29	20.9	20.1
30	21.6	20.8
31	22.3	21.5
32	23.0	22.2
33	23.7	22.9
34	24.5	23.6
Dist.	Dep.	Lat.
	46 Deg.	

Dist.	44 Deg. Lat.	Dep.
35	25.2	24.3
36	25.9	25.0
37	26.6	25.7
38	27.3	26.4
39	28.0	27.1
40	28.8	27.8
41	29.5	28.5
42	30.2	29.2
43	30.9	29.9
44	31.6	30.6
45	32.4	31.3
46	33.1	32.0
47	33.8	32.7
48	34.5	33.4
49	35.2	34.0
50	36.0	34.7
51	36.7	35.4
52	37.4	36.1
53	38.1	36.8
54	38.8	37.5
55	39.6	38.2
56	40.3	38.9
57	41.0	39.6
58	41.7	40.3
59	42.4	41.0
60	43.2	41.7
61	43.9	42.4
62	44.6	43.1
63	45.3	43.8
64	46.0	44.5
65	46.8	45.8
66	47.5	45.5
67	48.2	46.2
68	48.9	47.9
Dist.	Dep.	Lat.
	46 Deg.	

Dist.	44 Deg. Lat.	Dep.
69	49.6	47.9
70	50.3	48.6
71	51.1	49.3
72	51.8	50.0
73	52.5	50.7
74	53.2	51.4
75	53.9	52.1
76	54.7	52.8
77	55.4	53.5
78	56.1	54.2
79	56.8	54.9
80	57.5	55.6
81	58.3	56.3
82	59.0	57.0
83	59.7	57.7
84	60.4	58.4
85	61.1	59.0
86	61.9	59.7
87	62.6	60.4
88	63.3	61.1
89	64.0	61.8
90	64.7	62.5
91	65.5	63.2
92	66.2	63.9
93	66.9	64.6
94	67.6	65.3
95	68.3	66.0
96	69.0	66.7
97	69.8	67.4
98	70.5	68.1
99	71.2	68.8
100	71.9	69.5
200	143.9	138.9
300	215.8	208.4
Dist.	Dep.	Lat.
	46 Deg.	

Dif.	45 Deg. Lat.	Dep.
1	.7	.7
2	1.4	1.4
3	2.1	2.1
4	2.8	2.8
5	3.5	3.5
6	4.2	4.2
7	4.9	4.9
8	5.6	5.6
9	6.4	6.4
10	7.1	7.1
11	7.8	7.8
12	8.5	8.5
13	9.2	9.2
14	9.9	9.9
15	10.6	10.6
16	11.3	11.3
17	12.0	12.0
18	12.7	12.7
19	13.4	13.4
20	14.1	14.1
21	14.8	14.8
22	15.5	15.5
23	16.3	16.3
24	17.0	17.0
25	17.7	17.7
26	18.4	18.4
27	19.1	19.1
28	19.8	19.8
29	20.5	20.5
30	21.2	21.2
31	21.9	21.9
32	22.6	22.6
33	23.3	23.3
34	24.0	24.0
Dif.	Dep.	Lat.
	45 Deg.	

Dif.	45 Deg. Lat.	Dep.
35	24.7	24.7
36	25.4	5.4
37	26.1	26.1
38	26.8	26.8
39	27.5	27.5
40	28.3	28.3
41	29.0	29.0
42	29.7	29.7
43	30.4	30.4
44	31.1	31.1
45	31.8	31.8
46	32.5	32.5
47	33.2	33.2
48	33.9	33.9
49	34.6	34.6
50	35.3	35.3
51	36.0	36.0
52	36.7	36.7
53	37.5	37.5
54	38.2	38.2
55	38.9	38.9
56	39.6	39.6
57	40.3	40.3
58	41.0	41.0
59	41.7	41.7
60	42.4	42.4
61	43.1	43.1
62	43.8	43.8
63	44.5	44.5
64	45.2	45.2
65	45.9	45.9
66	46.6	45.6
67	47.4	47.4
68	48.1	48.1
Dif.	Dep.	Lat.
	45 Deg.	

Dif.	45 Deg. Lat.	Dep.
69	48.8	48.8
70	49.5	49.5
71	50.2	50.2
72	50.9	50.9
73	51.6	51.6
74	52.3	52.3
75	53.0	53.0
76	53.7	53.7
77	54.4	54.4
78	55.1	55.1
79	55.8	55.8
80	56.6	56.6
81	57.3	57.3
82	58.0	58.0
83	58.7	58.7
84	59.4	59.4
85	60.1	60.1
86	60.8	60.8
87	61.5	61.5
88	62.2	62.2
89	62.9	62.9
90	63.6	63.6
91	64.3	64.3
92	65.0	65.0
93	65.7	65.7
94	66.5	66.5
95	67.2	67.2
96	67.8	67.7
97	68.6	68.8
98	69.3	62.2
99	70.0	70.0
100	70.7	70.7
200	111.4	141.4
300	212.1	212.1
Dif.	Dep.	Lat.
	45 Deg.	

Now for the form of ſetting down a Reckoning, although he which is accuſtomed to keep it in this manner, may happily by uſe and practice diſcern how to order it in a better way than I can preſently preſcribe or think upon, becauſe he hath occaſion often to conſider it in every particular; yet in the mean time I conceive it will be fit to have a Book in *Folio*, that is, two Leaves to a ſheet of Paper, and keep the leſt ſide of your Book void, that you may write therein all ſuch Occurrences as you ſhall think requiſite. As namely, the Winds, and the Points of the Compaſs upon which your Ship lies, and what allowance you make for Leeward-way when you Sail by a Wind, the number of Glaſſes or Hours, or how many Knots or Miles in each Hour; alſo the Latitudes, which you find by Obſervation of the Meridian-altitude of the Stars, and what elſe you ſhall think remarkable. But before all this, the Title of the Voyage in theſe or the like words;

The Journal of our Voyage, intended by Gods aſſiſtance from S. I. *in the Latitude of* 32 *deg.* 25 *min. to the Coaſt of* England, *&c.*

The right hand Pages, or the right ſide of your Book throughout, may by Lines be divided into twelve Columns, as in the Example following doth appear. In the firſt Column may be expreſſed the Day, in the ſecond the Month; or at leaſt once in the top of the Page; likewiſe in the ſame ſecond Column, being large enough, may be ſet down the Latitudes, which you find by the Meridian-altitudes of Sun at ſuch times as you make Obſervation. In the third Column the Courſe (the Leeward-way, if there be any Leeing allowed.) In the fourth the Variation of the Needle. In the fifth (having made allowance for the Variation) ſet down the Angle of your Rumb with the Meridian. In the ſixth Column ſet down the diſtance in Miles run upon that Rumb. In the ſeventh, eighth, ninth and tenth Columns the Northing or Southing, Eaſting or Weſting, thereto anſwering, as you ſhall find it by your Table. In the eleventh your Latitudes by Dead-reckoning. And laſtly, in the twelfth Column you may at ſuch times as you think fitteſt, ſet down your Longitude from the place from which you firſt departed, or the difference of Longitude from place to place.

Day.

da.	Lat. by observation.	course	Variation.	Deg. from the merid	di. in miles	Nor.	Sou.	East	Weſt	Lat. by dead Reckonde.	Longitude.
20	Februar)	N E by E	8deg. weſt	ne 48d	78	522		579		33.17	
21	Latitude 34 d. 25'	N E by E	8deg weſt	ne 48c	100	669		743		34.24	
21	34 d. 25			Summe is		1191		1322		34.24	02.38
22		ene ½ poi.	8deg. weſt	ne 54d	100	588		809		35.56	
					56	329		453			
23	Latitude 37 d. 46	ene ½ no.	8deg weſt	ne 54d	100	588		809		37.40	
					78	458		631			
24	Latitude 39 d. 36	ene ½ no.	8deg. weſt	ne 54d	100	588		809		39.28	
					84	494		679			
				Summe is		3045		1419			
				The correction by obſer.		16	80	11	10	08	
24	39.36					3125		1430		39.36	1.36
25	February	ene	8deg. weſt	ne 59½	100	507		861		41.05	
					76	385		655			
26		ene	8deg. weſt	ne 59½	100	507		861		42.37	
					80	412		686			
27	Latitude 43 d. 55	ene	7½deg weſt	ne 60c	100	500		866		44.09	
					84	420		728			
				Summe is		2731		1465	7		
				Correction		11	40	12	45	14	
27	L. 43.55					2591		1441	2	43.55	21.28
28	February	ene ½ e	6deg weſt	ne 67 d	100	391		921		44.54	
					51	199		469			
29		ene ½ e	5deg. weſt	ne 68 d	100	375		927		46.02	
					81	304		751			
1	March	ene ½ e	4deg weſt	ne 69 d	100	358		934		47.02	
					66	237		616			
2	La. 48.4.	ene ½ e	2deg. weſt	ne 71 d	100	326		946		48.00	
					78	254		737			
2	La. 48.4.			Summe is		2444		1630	1	48.00	36.38

da.	Lat. by observation.	cours.	Variation.	Deg. from the Mer.	d. in miles	Nor.	Sou.	East	West	Lat by dead R.	Longitude.
3	March	e n e ½ e	0 de. west	n e 73 d	100 52	292 152		956 497		48.44	
4		e n e ½ e	2 de East	n e 75 d	100 68	259 176		966 657		49.28	
5	Latitude 49°. 58′	e n e ½ e	3 de. East	n e 76 d	98	237		951		49.52	
				Summe is		1116		4027		49.52	46.52
5	la. 49. 58										
5	8 Hours	n by e ½ e	4 de. East	n e 21 d	18	168		64		50.09	
6		south by e	4 de East	s e 7 d.	34		337	41		49.35	
6	16 Hours	n by east	4 de. East	n e 15 d	36	348		93		50.10	
7		se by east	4 de. East	s e 52 d	20		123	158		49.58	
8	Latitude 50 d. 4′	East	4 de. East	s e 86 d	96		67	958		49.51	
	The current setting by estima.	East nort. east.		n e 67 ½	60	230		554		50.14	
				Summe is		219		1868			
				Correction			100			10′	
8	l. 50 d. 4					119		1868		50 04	51 43
9		east ½ po. n	6 de East	s e 89 ½ d	70		60	700		49.58	
10		east ½ po. n	6 de East	s e 89 ½ d	52		41	520		49.54	
10	March			Summe is			101	1220		49.54	54.53
	Here the Lizard bears	N by E			13						

For

For an Example, we may frame a Reckoning between the two places before-mentioned, namely, from *Summer Iſlands* to the *Lizard*, whoſe diſtance in the Rumb we have before ſuppoſed to be 3299 Miles, as ſome *Charts* make it, and conſequently their difference of Longitude 70 deg. I would not be underſtood as if I affirmed it to be ſo much, for I ſuppoſe it is leſs. I was there indeed about 20 years paſt, and Surveyed it, and then kept a Reckoning both outwards and homewards, but I have loſt thoſe Reckonings long ſince, and have forgotten what they were, and in this caſe it matters not; for whether the ſuppoſition be near the truth or not, it ſerves ſufficiently to exemplifie the Rule, that being the end for which it is uſed. But if their diſtance be 3299 ſuch Miles as contain only 1000 Paces in a Mile, the ſame being reckoned in ſuch Miles, as we have before mentioned, namely, in ſuch whereof 60 make a degree of a great Circle, which as we find contains 6120 Feet in a Mile, their diſtance will be little more than 2695 Miles; and conſequently, the difference of Longitude little more than $55\frac{1}{2}$ degrees.

Let us therefore ſuppoſe the difference of Longitude between thoſe two places to be 55 degrees, and their Latitudes to be the ſame as before; namely, of the one 32 deg. 25 min. and of the other 50 degrees. And let the Courſes, Diſtances, and other Obſervations from *Summer Iſlands* to the *Lizard* be ſuch as before is ſhewed.

The firſt entrance in this Journal (which is the 20*th* day of *February*) is thus to be underſtood; namely, that from the time of ſetting Sail (which we ſuppoſe to be the 19*th* of *February*) till the 20*th* day at Noon, the Ship lies away, and makes her way good upon the North-Eaſt-and-by-Eaſt Point of the Compaſs; but the Variation being 8 degrees to the Weſtwards (as in the fourth Column appears) the Rumb upon which ſhe hath run is from the North to the Eaſtwards only 48 deg. as is expreſſed in the fifth Column (it is indeed $48\frac{1}{4}$ deg. but the $\frac{1}{4}$ deg. we omit, as for the other circumſtances not to be regarded) upon this Rumb ſhe runs 78 Miles, as in the ſixth Column appears; and anſwerable thereto I find in the Table before going the Northing to be $52\frac{8}{10}$ Miles, and the Eaſting $57\frac{9}{10}$, as here in the ſeventh and ninth Column is expreſſed by theſe numbers 522 and 579 (for the firſt Figure towards

towards the right hand ſignifieth the tenth part of a Mile, the reſt Miles.) Hence then the Northing being 52 miles, if that be added to the Latitude from which it is reckoned, namely, 32 deg. 25 min.' it makes the Latitude here to be 33 deg. 17 min. as in the eleventh Column appears. In like ſort, the ſecond entrance being the 21 of *February*, ſheweth that from the 20 day at Noon to the 21, ſhe made her way good upon the North-Eaſt-and-by-Eaſt Point of the Compaſs; but the Variation being 8 degrees Weſterly, the Angle of the Rumb with the true Meridian was from the North to the Eaſtwards 48 degrees; and ſo Sailing 100 miles, the Northing is 69 $\frac{2}{10}$ miles, and the Eaſting 74 $\frac{1}{10}$ miles; ſo that the Latitude is now 34 deg. 24 min. and the like is to be underſtood of all the reſt.

Touching the Longitude, expreſſed in the laſt Column, although a Reckoning may be kept and ſet down without it, yet it is of very good uſe; and how to convert the Eaſting or Weſting (that is, the Miles expreſſed in the Eaſt and Weſt Columns of your Journal) into Degrees and Minutes of Longitude, we will ſhew afterwards, as alſo how you may eaſily correct your Courſe, and give the true Courſe or Rumb, allowing the Variation.

But firſt to proceed with this Journal, obſerving the Meridian altitude of the Sun upon the 23 and 24 of *February*, I find that my Latitude upon the 24, is 39 deg. 36 min. whereas by Dead-reckoning it is but 39 deg. 28 min. ſo the difference is 8 more Northerly: But being well aſſured of the Latitude found by Obſervation, I correct the Dead-reckoning thereby, which may be done by the Rule of Proportion, ſaying;

As the Sum of the North Column,	3125	*Co. ar.*	6.50515
to the Sum of the Eaſt Column,	4300		3.63347
So the foreſaid Increaſe Northerly,	80		1.90309
to the Increaſe Eaſterly	110		2.04171

That is, 11 miles; for the firſt place towards the right hand is only for the tenth part of a mile.

The ſame may alſo ſufficiently be found without the Rule of Proportion, by the foregoing Table, only for looking there under the Degree upon which I have Sailed, namely, under 54 deg. for 8 miles or 80 tenths of a mile, though I find not the ſame

exactly, yet I find one which is near it, namely, 82, and againſt it in the next collateral Column 113, which is 11 $\frac{3}{10}$ miles (being too much by $\frac{2}{10}$ of a mile, becauſe the other is too much by $\frac{2}{10}$;) I add therefore in the North Column of the Journal 8 miles, and the Eaſt Column 11 miles; and ſo whereas by Dead-reckoning, the Northing was but 304 $\frac{1}{10}$ miles, and the Eaſting 194 miles; now having corrected it by Obſervation, the Northing is 312 $\frac{1}{10}$ miles, and Eaſting 430 miles.

In like ſort upon the 27 day, I ſhould by Dead-reckoning be in the Latitude of 44 deg. 9 min. but by a clear and good Obſervation I find my ſelf in the Latitude of 43 deg. 55 min. that is, not ſo much Northerly by 14 min. therefore to correct it, I put in the South Column 14 miles or 140 tenths, and ſeeing my Courſe was between the North and the Eaſt, and that I find my ſelf to be leſs to the Northwards, that is, more to the Southwards than my Reckoning; therefore in probability I am alſo leſs to the Eaſtwards, that is, more to the Weſtwards than my Reckoning; but to find how much, I look in the foregoing Table for the degree upon which I have Sailed, being from the North part of the Meridian to the Eaſtwards 60 deg. and under 60 deg. I look for 14 miles, or 140 tenths, and againſt it in the Column adjoyning I find 243, which I ſet down in my Journal in the Weſt Column, and ſo ſubtracting the firſt from the North Column, the other from the Eaſt, I find, that whereas by Dead-reckoning I ſhoud be to the Northwards 273 $\frac{1}{10}$ miles, and to the Eaſtwards 465 $\frac{7}{10}$. Now having corrected it by Obſervation, I find that from the 24 day till this time I have run more Northerly than I was by 259 $\frac{1}{10}$ miles, and more Eaſterly by 441 $\frac{8}{10}$ miles.

But if your Courſe be near the Eaſt or Weſt, it may ſuffice to correct it in Latitude only, as in the Example of the 8 of *March* appears; for in that caſe you cannot correct the Longitude, but from ſome further ground.

If there be any Current, you may note it, as it is done in that Example following the 8 of *March*.

Now if you would ſet down this Reckoning upon the plain or common *Sea-Chart*; Firſt, if you deſire to expreſs every days Account, you may begin for the 20 of *February*, and make a prick in your Plot that may be from the place from which you ſet Sail,

to

to the Northwards 52 $\frac{8}{10}$ miles, and to the Eaſtwards 57 $\frac{2}{10}$; and ſo will this Point be diſtant from the place of your ſetting Sail 78 miles Eaſt, and almoſt a quarter of a Point Eaſterly: then for the 21 day you may make another Prick, which may be from the form to the Northwards 66 $\frac{2}{10}$ miles, and to the Eaſtwards 74 $\frac{3}{10}$ miles, and ſo you may proceed with the reſt. And thus you ſhall have a Prick on the Plot for every day more exactly ſet down, than could be done after the ordinary way by Courſe and Diſtance, or Courſe and Latitude; eſpecially becauſe in lining the Plot, there are not, nor cannot conveniently be drawn any more than the 32 Points of the Compaſs, *viz.* not half-Points, quarters, or ſingle degrees.

But if you deſire not to ſet down every Days Reckoning (which is not neceſſary to be done) you may ſet down every of the Sums as they are corrected by Obſervation, after the ſelf-ſame manner.

Or you may add together all thoſe Sums, and ſo the Sum-total of the North-Column will be 1049 miles, and of the Eaſt Column 2345 miles: therefore in the Meridian of the place from which you depart, you may ſet down to the Northwards of that place 1049 miles, which will fall in the Latitude of 49 deg. 54 min. almoſt, and from thence in that Parallel ſet down directly to the Eaſtwards 2345 miles, and there make a Prick for the place where the Ship then is the tenth of *March*; and ſo is all this Reckoning ſet down at once.

If you keep Reckoning according to *Mercator*, it will be requiſite ſometimes to ſum up your Reckonings paſt, namely, ſo often as you make any notable alteration in your Courſe; and ſo this Reckoning or any other may be ſet down, almoſt as eaſily on *Mercator's Chart*; the difference is, that here you muſt often alter your *Scale*, becauſe the degrees of Latitude on this *Chart* are not equal, but grow greater and greater towards the Poles. Now then the diſtance between two places is to be meaſured by that part of the Meridian, which is intercepted between the Latitudes of thoſe two places: Or if both places lie in one and the ſame Latitude, their diſtance is meaſured by a degree or other leſs quantity, taken about that Latitude; namely, half above, and half beneath.

Wherefore if you would make a Prick or Traverſe-point in *Mercator's Chart*, anſwering to your Reckoning for the firſt day,

namely, until the 20 of *February* at Noon; it appears by you Journal that Prick muſt be to the Northwards of the place from which you departed 52 $\frac{8}{10}$ miles, and to the Eaſtwards 57 $\frac{9}{10}$ miles.

Now inſtead of the North or South Columns, you may more conveniently uſe the laſt Column but one, ſhewing in what Latitude every Account doth fall; and ſo it appears, that the Prick for the 20 of *February* muſt be in the Latitude of 33 deg. 17 min. Therefore in the Meridian of the *Summer-Iſlands* from which you departed, make a Prick in the Latitude of 33 deg. 17 min. and from that Prick ſet down to the Eaſtwards in the ſame Latitude 57 $\frac{9}{10}$ miles, and where it ends is the Traverſe-point anſwering to the 20 of *February*: the like may be done for the 21 day, and ſo for all the reſt. This 58 miles may be taken in the Meridian from the Latitude of 32 deg. 22 min. to the Latitude of 33 deg. 20 min. or otherwiſe you may take the half of it, which is 29 miles, about the middle between both Latitudes, and double it.

But it is ſufficient to ſet down the Sums of every two or three Days Account, or ſo often as there is any notable Difference in your Courſe. Thus if you would make a Prick in the *Chart*, anſwering to the 21 of *February* being the firſt Sum; I ſee by the Journal, that it muſt be in the Latitude of 34 deg. 24 min. and to the Eaſtwards of the place from which I departed 132 $\frac{8}{10}$ miles. Therefore in the Meridian of the place from whence I departed, I make a Prick in the Latitude 34 deg. 24 min. and from that Prick I ſet in the ſame Latitude to the Eaſtwards 132 $\frac{8}{10}$ miles, and where it ends is the Traverſe-point anſwering to the 21 of *February*, being the firſt Sum. This 132 miles may be taken in the Meridian, within, or a little without the two Latitudes, as before, namely, from 32 deg. 20 min. to 43 deg. 32 min.

In like ſort, if you would make a Prick for the ſecond Sum, being the 24 of *February*, it there appears that it muſt be in the Latitude of 39 deg. 36 min. and to the Eaſtwards of the Traverſe-point laſt before made 430 miles; therefore in the Meridian of that Traverſe-point I make a Prick in the Latitude of 39 deg. 36 min. and from that Prick I ſet to the Eaſtwards in the ſame Latitude 430 miles, and where that ends is the Traverſe-point anſwering to the 24 day, and the like is to be underſtood of all the reſt.

Now

Now this 430 miles may be taken ſeveral ways; for firſt, If I take 1 degree about the middle of that part of the Meridian, which is intercepted between the Latitudes of the two places (as from 36 deg. 30 min. to 37 deg. 30 min.) and that degree ſeven times taken, is 420 miles; then about the middle, namely, 37 deg. I take 10 min. more, and ſo have 430 miles.

In like manner you may take 2 deg. or 120 miles to meaſure it thereby, which may be taken from 36 deg. to 38 deg. and the reſidue about 37 deg. as before, *&c.*

Or you may take the half of 430 miles, namely, 215 miles, which is 3 deg. 35 min. which muſt be taken as before, about the middle part of the Meridian which is intercepted between the two Latitudes, and that doubled is 430 miles to be ſet to the Eaſtwards, as before.

And thus may this or any other Reckoning be ſet down without knowledge of the Longitudes, but more aptly and exactly by ſome Longitudes known; for then ſhall you have in the two laſt Columns the ſubſtance and principal ſcope of your Reckoning, namely, the Latitudes and Longitudes of all places, as you Sail, which may more eaſily and exactly be expreſs'd upon this *Chart*, than the Eaſterly or Weſterly diſtances: Therefore how this alſo may be done, we will ſhew, but firſt ſomething touching the *Compaſs*, and the Variation thereof, which ought not to be neglected in a Reckoning.

CHAP. X.

Of the Variation of the Compaſs, and how to rectifie a Courſe by the Variation known.

AMongſt all the Myſteries which God hath of late years diſcovered to the World for the furtherance of *Navigation*, there is none more neceſſary, nor yet more admirable than the property of the *Needle* touched with the Load-ſtone, whereby in the vaſt Ocean, where all the Land-marks

marks fail, yea even in the darkeſt nights and cloſeſt weather, when neither Sun nor Stars are to be ſeen, the Mariner (as it were by a Meſſenger ſent from Heaven) is taught which way to direct his Ship; yea, as it were accompanied with a Guide towards his deſired Port.

For the Needle touched, beſides other ſtrange properties, hath this, to point out in all quarters of the World, the North and South parts of the Horizon, and ſo having a Card thereto fitted with Rumbs and Degrees, it ſheweth all Points of the Compaſs, and Degrees of the Horizon.

Yet very ſeldom exactly of it ſelf, without ſome farther Art and Induſtry of him that uſeth it; for though in ſome places it ſwerves not, yet in moſt parts of the World the North and South Points of the Needle have ſome Variation from the true North and South Points of the Horizon to the Eaſtwards or to the Weſtwards, which how to diſcover in kind and quantity, we have ſhewed heretofore.

It may be thought, (and ſome men, otherwiſe learned, before this property was fully diſcovered, have ſaid) that this ſhould be ſome blemiſh and imperfection in a Stone ſo precious; but it is ſo ſo far from being an imperfection, that it makes it ſo much the more precious: yet (as I have ſaid) not without the induſtry of him that uſeth it. He that is negligent or unskilful to obſerve it, eſpecially in long Voyages and various Courſes, may be led into many dangers by it, becauſe he frames not his mind to the Rule, but the Rule to his mind, imagining it to be what it is not: And hence I ſuppoſe ſprang that cuſtom of placing the Needle or Wiers a Point or half a Point the Eaſtwards of the North-Point of the Card, thinking by this means to ſhun the labour of obſerving the Variation, which indeed they might, if the Variation were the ſame in all places, and at all times; but becauſe it is not, this doth often increaſe the Error.

But he that diligently obſerves the Variation, finds (as I ſay) no prejudice in it, only it requires daily, or once in two or three days half an hours work; and this labour it doth abundantly recompenſe; for by this means he knows at the preſent how to direct his Courſe, and for the future, by thoſe Notes which he keeps of the Variations and Latitudes by him obſerved, he knows (coming

that

that way again) when he draws near to any of thoſe places where ſuch Obſervations were made, and ſo falls the more certainly with any place intended.

There is further diſcovered of late a motion or alteration in the Variation of the Needle, and this is ſcarce yet certainly diſcovered. But comparing the Obſervations which were obſerved about fifty years paſt, with the preſent Variation, it appears they are leſſer Eaſterly, and more Weſterly by 6 or 7 degrees, than they were at that time. For whereas the Variation hath formerly been obſerved near *London* to be $11\frac{1}{4}$ deg. to the Eaſtwards, it doth now ſcarce exceed 4 degrees. And there is the like alteration (as I have heard by ſome Mariners) in other parts of the World; which we now leave to the farther diſcovery of time and induſtry, and come to ſhew how to rectifie a Courſe by the Variation known.

The Point of the Compaſs upon which you ſail, and the Variation of the Needle known, to find the Rumb or Degree upon which the Ship hath made her way.

IT is beſt that the Needle or Wiers be placed directly under the Flower-de-luce, or North and South Points of the Card, and ſo in the Rules following we preſuppoſe them to be. Now then it is to be underſtood, that the Needle having Variation (as for the moſt part it hath) the Ship doth not make her way upon that Rumb or Point of the Compaſs, which ſhe ſeems to Sail upon, but either more to the right hand or to the left, according as the Variation is towards the right hand, or towards the left, and that ſo much towards the one ſide, or towards the other as that Variation is: We ſpeak not here of Leeward-way, but of the Variation only. Therefore for the ſolution of this *Problem*, you muſt know how the Variation is, and which way; and how this may be done, we have briefly ſhewed upon the 12*th* Caſe of Right-angled Spherical Triangles, and the 11*th* of Oblique, which known, you may find the Angle of the Rumb or Line of your Ships way, with the Meridian, being the thing in this *Problem* required.

A Table

A Table of the Angles of every Point and half Point of the Compass with the Meridian.

	North.	South.	D. M	North.	South.
1	N by E	S by W	00 00	N by W	S by E
1½			05 37		
2	NNE	SSW	11 15	NNW	SSE
2½			16 52		
3	NE by N	SW by S	22 30	NW by N	SE by S
3½			28 07		
4	NE	SW	33 45	NW	SE
4½			39 22		
5	NE by E	SW by W	45 00	NW by W	SE by E
5½			50 37		
6	ENE	WSW	56 15	WNW	ESE
6½			61 52		
7	E by N	W by S	67 30	W by N	E by S
7½			73 07		
8	East.	West	78 45	West.	East.
	Add East Variation, Substract West.		84 22 90 00	Add West Variation, Substract East.	

For the effecting whereof, we will set down two ways; the one by the Pen alone, the other instrumentally. If you do it by the Pen alone, although it be not hard to find what Angle every Point or half-Point makes with the Meridian; yet for your further ease herein, I have expressed the same in the Table before-going; the quarters of Points I have omitted, because the Steerage upon a quarter of a Point is very uncertain (the Points being undivided as usually they are) for a man is able by his Eye to guess very nearly which is the middle between two Points, but he cannot guess so nearly which is the fourth part. Yet if you desire

any

any quarter, you may add to the next before-going almoſt 3 degrees; namely, 2 deg. 49 min.

Now then by the Magnetical Rumb or Point of the Compaſs and Variation given, to find the Rumb, you are to obſerve theſe two Rules following.

1. *If the Rumb and Variation be both the ſame way from the Meridian (namely, both to the right hand, or both to the left) add them together, and that Sum is the true Rumb from that part of the Meridian.*

Yet if that Sum exceed 90 *degrees, ſubtract it from* 180 *degrees, the Remainder is the Rumb from the oppoſite part of the Meridian.*

2. *If the one be towards the right hand, the other towards the left, ſubtract the Variation from the Rumb, and the Remainder is the true Rumb.*

Yet if the Rumb be the ſmaller number, ſubtract it from the Variation, and the Remainder is the true number the other way.

Theſe Rules we ſhall endeavour to illuſtrate by Examples following.

But firſt for diſtinction ſake, we ſay the Rumbs or Degrees from the North towards the Eaſt, are towards the right hand, and ſo from the South towards the Weſt, but from the North to the Weſtwards on the left hand, and ſo from the South Eaſtwards: For a mans face being towards the North, the Eaſt is on his right hand, and the Weſt on his left, *&c.*

In like ſort for the Variation of the Compaſs, if it have Eaſterly Variation, that is, if the Needle and Flower-de-luce of the Card ſtand to the Eaſtwards of the North, we ſay that Variation is towards the right hand, for not only the North-Point, but all the other Points of the Compaſs direct a Courſe more towards the right hand than they would do, if there were no Variation. And ſo if it have Weſterly Variation, that is, if the Needle and Flower-de-luce ſtand to the Weſtwards of the true North-Point of the Horizon, we ſay that Variation is towards the left hand; foraſmuch as not only the North-Point, but all the other Points of the Compaſs ſtand more towards the left hand than they would do, if there were no Variation. This being premiſed, we come to give Examples of the two Rules before-going.

1 *Example.* Let the Magnetical Rumb or Point of the Compaſs be North-Eaſt, and the Variation 10 degrees to the Eaſtwards, I demand the true Rumb?

Here the Rumb and Variation are both one way; that is, both towards the right hand; therefore,

To the Magnetical Rumb being North-Eaſterly	45 deg. 00 min.
Add the Variation Eaſterly	10 deg. 00 min.
The ſum is the true Rumb North-Eaſterly	55 deg. 00 min.

2 *Example.* Admit a Ship ſail upon the North-Point of the Compaſs, and that the Variation be 10 deg. to the Eaſtwards; how doth ſhe make her way?

The Magnetical Rumb is North, that is,	00 deg. 00 min.
To which adding the Eaſterly Variation	10 deg. 00 min.
The ſum is the Angle from the North-part of the Meridian to the Eaſtwards	10 deg. 00 min.

Which is almoſt *N.* by *E.* and ſo hath the Ship made her way.

3 *Example.* Let the Point of the Compaſs be Eaſt ½ Point Northerly, that is, from the North to the Eaſtwards 7½ Points, which is 84 deg. 22 min. and the Variation as before 10 deg. to the Eaſtwards; I demand the true Rumb?

To the Magnetical Rumb, being North-Eaſt,	84. deg. 22 min.
Add the Eaſterly Variation	10 deg. 00 min.
The ſum is the Angle from the North	94 deg. 22 min.
Which ſubtracted from	180 deg. 00 min.
There reſts the true Rumb South-Eaſterly	85 deg. 38 min.

4 *Example.* Let the Courſe by the Compaſs be Weſt and by South, that is, 7 Points from the South to the Weſtwards, or 78 deg. 45 min. and let the Variation be as before, 10 deg. to the Eaſtwards; what is the true Rumb?

To the Magnetical Rumb South-Weſterly	78 deg. 45 min.
Add the Eaſterly Variation	10 deg. 00 min.
The ſum is the true Rumb South-Weſterly	88 deg. 45 min.

You may conceive that the Rumb and Variation are here both one way; namely, both from the Meridian towards the right hand. For the Variation of the North-point is from the North towards

towards the East, and consequently of the South-point from the South towards the West, both towards the right hand of the Meridian, as the Rumb is.

5 *Example.* Let the Course by the Compass be West, that is, from the South to the Westwards 8 points or 90 degrees, and let the Variation be as before, 10 deg. to the Eastwards; I would know the true Course or Rumb?

To the Magnetical Rumb South-West	90 deg. 00 min.
Add the Variation Easterly	10 deg. 00 min.
The sum is the Angle with the South-part of the Meridian	100 deg. 00 min.
Which subtracted from	180 deg. 00 min.
There rests the true Rumb North-West	80 deg. 00 min.

Let the Course of the Compass be West, that is, from the North to the Westwards 8 points or 90 degrees, and let the Variation be 10 deg. to the Westwards; I demand the true Rumb?

To the Magnetical Rumb North-West	90 deg. 00 min.
Add the Variation Westerly	10 deg. 00 min.
The sum is	100 deg. 00 min.
Which subtracted from	180 deg. 00 min.
There remains the true Rumb South-West	80 deg. 00 min.

Object. The Magnetical Rumb being here West 90 deg. why should it not as well be counted from the South, as from the North?

Answ. It may be counted from either; for as it is counted here from the North to the Westwards, it falls under the first Rule, because the Variation is the same way: But if it be reckoned from the South to the Westwards, it falls under the second Rule, whereof we now come to give some Examples, supposing these already given sufficient to illustrate the first Rule.

7 *Example.* Let the Point of the Compass by *N. N. W.* and the Variation 10 deg. Easterly; I demand the true Rumb?

From the Magnetical Rumb North-West	22 deg. 30 min.
Subtract the Easterly Variation	10 deg. 00 min.
The Remainder is the true Rumb North-West	12 deg. 39 min.

8 *Example.* Let the Point of the Compass be North, and the Variation Easterly 10 deg. what is the true Rumb?

From the Eaſterly Variation	10 deg. 00 min.
Subtract the Magnetical Rumb, *NW*	00 deg. 00 min.
The Remainder is the true Rumb, the other way, namely, *NE*	10 deg. 00 min.

Object. The magnetical Rumb may as well be named North-Eaſterly 0 deg. 0 min.

Anſw. It may, but then it is ſubject to the firſt Rule, as in the ſecond Example.

9 *Example.* Let the Courſe of the Compaſs be Weſt, that is, from the North to the Weſtwards 8 Points or 90 Degrees, and let the Variation be as before 10 deg. to the Eaſtwards, what is the true Rumb?

From the Magnetical Rumb *NW*	90 deg. 00 min.
Subtract the Eaſterly Variation	10 deg. 00 min.
There reſts the true Rumb *NW*	80 deg. 00 min.

Here the magnetical Rumb might as well been South-weſterly 90 deg. and ſo it had fallen under the firſt Rule, as in the fifth Example.

10 *Example.* Let the Courſe by the Compaſs be Weſt, that is, from the South to the Weſtwards 8 Points or 90 degrees, and let the Variation be 10 deg. to the Weſtwards, I demand the true Rumb?

From the Magnetical Rumb *SW*	90 deg. 00 min.
Subtract the Weſterly Variation	10 deg. 00 min.
The Remainder is the true Rumb *SW*	80 deg. 00 min.

If the Rumb here had been reckoned from the North, as in the fifth Example, it had fallen under the firſt Rule.

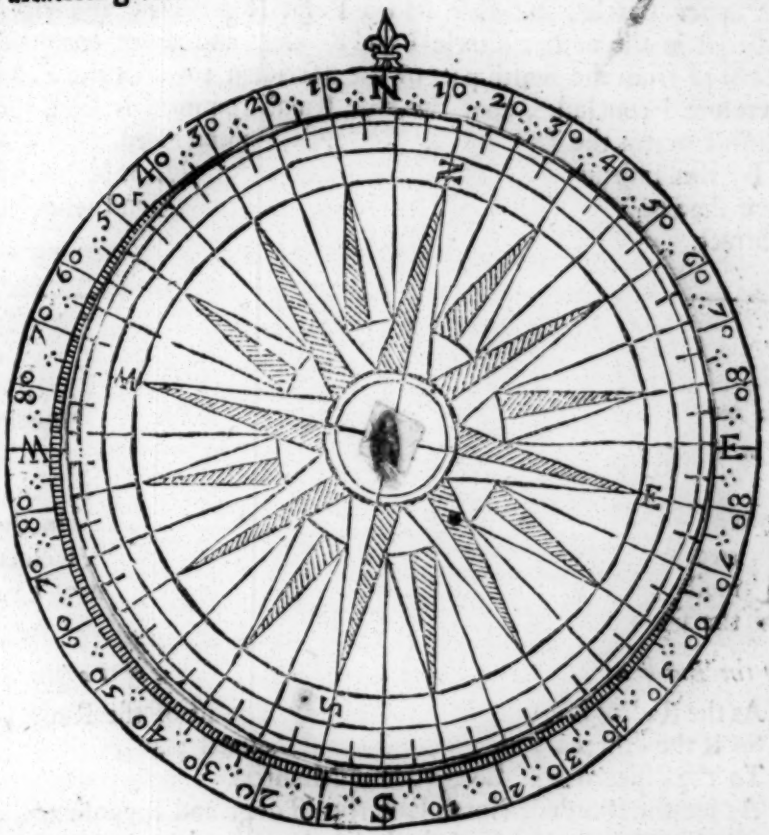
And this may ſuffice for the illuſtration of the two former Rules in the ſolution of this Problem.

The ſame may alſo more eaſily be reſolved, by ſuch an Inſtrument as is here deſcribed, conſiſting of two Circles; the one, being the nethermoſt, divided into 4 Quadrants, and every of thoſe into 90 deg. numbred from the North and South Points, towards the Eaſt and Weſt.

The other, being the uppermoſt, and moveable about the Centre, divided as the Card of the Compaſs into XXXII Points, and thoſe again ſubdivided into halves and quarters.

By

By this you may readily find the true Rumb for any Courſe and Variation given.



For if you turn the North-Point of the upper Circle, from the North-Point of the lower, ſo many deg. and the ſame way that the Variation is, and then look in the ſame upper Circle for the Magnetical Courſe or Point of the Compaſs propoſed, you ſhall find right under it in the nether Circle what number of degrees the ſame is diſtant from the *N.* or *S.* Points of the true Meridian towards the *E.* or *W.* which is the true Rumb here required.

As ſuppoſe the Variation to be 10 deg. Eaſterly, and the Courſe by the Compaſs Eaſt half a Point Northerly, and there be required the true Rumb.

I turn

I turn to the North-point of the upper Circle from the North-point of the lower 10 deg. to the Eaſtwards, and then I look in the upper Circle, for Eaſt half a Point Northerly, and right under it in the nether Circle I find 85 deg. and about one half, numbred from the South-part of the Meridian towards the Eaſt; therefore I conclude, that the true Rumb required is from the South towards the Eaſt, 85 ½ deg. and ſomething more.

By this Inſtrument alſo (if you uſe the Pen only, as before we have ſhewed) you ſhall readily ſee when to add, and when to ſubtract.

CHAP. XI.

To keep a Reckoning of your Longitude, and ſo to ſet down a Reckoning by Longitude and Latitude.

IN the Example before given of a Journal, we have in the twelfth and laſt Column expreſſed in ſuch places as it ſeemed moſt requiſite, the Longitudes, we come now to ſhew how the ſame may be known; and firſt,

By the Rumb and Latitude given, to find the difference of Longitude.

As the Radius is in proportion, to the Tangent of the Rumb;
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As let the Rumb be North-Eaſterly 48 deg. and ſuppoſe a Ship to run upon this Rumb, from the Latitude of 32 deg. 25 min. into the Latitude of 34 deg. 24 min. there is required the difference of Longitude. Here,

The Meridional parts anſwering to	34 deg.	24 min.	2200
The Meridional parts for	32	25	2058
The difference of Latitude in ſuch parts is			142

Say then, As Radius is in proportion,

To the Tangent of the Rumb, *t.* 48 deg. 00 min.		10.0456
So the difference of Latitude in Merid. parts,	142	2.1523
To the difference of Longitude in Minutes	158	2.1979

Theſe

Theſe Minutes converted into deg. are 2 deg. 38 min. which is the difference of Longitude required, as the ſame is expreſſed in the Journal againſt the 21 of *February*.

And thus Sailing upon one and the ſame Rumb, you may find the difference of Longitude, and ſo often as you alter your Rumb, ſo often working by the ſame Rule, you ſhall have all the differences from place to place, which added together, make the whole difference of Longitude.

But you may alſo find the difference of Longitude near enough at one Operation for many ſeveral Rumbs and Diſtances, provided that thoſe Rumbs differ not much one from another. As in the former Journal from the 27 of *February*, till the 2 of *March*, I ſail by ſeveral Rumbs and Diſtances from the Latitude of 43 deg. 55 min. into the Latitude of 48 deg. if you would find the difference of Longitude hereto anſwerable at one Operation, it may be done by this Rule.

As the difference of Longitude in Miles,
Is to the departure from the Meridian in Miles;
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As in that Example the difference of Latitude for all thoſe Courſes, as in the North Column appears, is 2444.

The departure from the Meridian, as there in the Eaſt Column appears, is 6301.

The Merid. parts for the Latitude of 43 deg. 55 min. are			2939
The Merid. parts for the Latitude of 58 deg. 00 min. are			3292
The difference of Latitude in Meridional parts, is			353
Say then, As the difference of Latitude	2444	*co. ar.*	6.6119
To the departure from the Meridian	6301		3.7994
So the difference of Latit. in Merid. parts	353		2.5478
To the difference of Longitude in min.	910		2.9591

Which reduced into degrees, is 15 deg. 10 min. And added to the former Longitude 21 deg. 48 min. gives the preſent Longitude 36 deg. 28 min. for the 2 of *March*.

The like may be done for the Account from the 2 of *March*, to the 5 of the ſame, *&c.*

But-

But if your Courſes and Diſtances run, be all near to one and the ſame Parallel or Latitude (as in this Journal they are from the 5 of *March* to the 8, and from the 8 to the 10,) then it is ſufficient to find what Longitude in that Parallel is anſwerable to the Miles of Eaſting or Weſting, or departure from the Meridian by this Rule:

As the Sine Complement of the Latitude of that Parallel,
Is in proportion to *Radius*;
So is the number of Miles in that Parallel,
To the difference of Longitude in Minutes.

As from the 5 of *March*, to the 8, the Latitude was near 50 deg. the Eaſterly diſtance 186 $\frac{8}{10}$ miles: therefore for the difference of Longitude, ſay;

As Sine Complement the Latitude, *s. c.* 50 deg. 0 min.			1919
To *Radius*,			
So is the departure from the Meridian	186	8	3.2714
To the difference of Longitude	290	6	3.4633

Thus it appears, the difference of Longitude is almoſt 291 min. which is 4 deg. 51 min. and this added to the Longitude upon the 5 of *March*, namely, to 46 deg. 52 min. the ſum is 51 deg. 43 min. the Longitude for the 8 of *March*: the like might be done for the 10 of *March*.

And though this laſt Rule be then fitteſt to be uſed, when your Courſe is near Eaſt and Weſt, or your difference of Latitude little, yet it may alſo be uſed at other times inſtead of the two former, without any great Error, if you take the middle degree of Latitude, or ſomewhat more, as in the former Example.

The Latitude upon the 27 of *February* is	43 deg. 55 min.
The Latitude upon the 2 of *March* is	48 deg. 00 min.
The middle Latitude, or ſomewhat more, is	46 deg. 10 min.

Say then;

As Sine Complement the Latitude *s. c.* 46 deg. 10 min.			1595
To *Radius*;			
So the Eaſting or departure from the Merid.	630	1	3.7994
To the difference of Longitude	909	7	3.9589

Which is almoſt 910 min. or 15 deg. 10 min. as before.

And

And thus you may in the twelfth and laſt Column of your Journal ſet down your Longitude, ſo often as you think is requiſite; and ſo in the two laſt Columns you ſhall have the ſubſtance and principal ſcope of your Reckoning, namely, your Latitudes and Longitudes, which whenſoever you deſire to ſet down in *Mercator's Chart*, or in the *Polar Chart*, or in any other, graduated with Degrees of Longitude and Latitude, as you may readily do it.

As if you would ſet down the ſum of the foreſaid Journal from the 19 of *February* to the 10 of *March*, I find againſt the 10 of *March* the Latitude to be 49 deg. 54 min. and the difference of Longitude 54 deg. 53 min. Therefore in the Latitude of 49 deg. 54 min. I draw an occult Parallel, and reckoning from *Summer-Iſlands* towards the Eaſt 54 deg. 53 min. I draw by that Longitude an occult Meridian; the Interſection of this Meridian with the foreſaid Parallel, is the Traverſe-point, or the Point repreſenting the place of the Ship: and the like is to be underſtood of any other.

This form of keeping and expreſſing a Reckoning, is (as I concieve) moſt apt and agreeable (of all others that I have ſeen or thought upon) to all ſorts of *Charts* or *Maps*, and to the *Globe* it ſelf; and to all the kinds or ways of Sailing, that are or may be uſed. We will here add ſome other Propoſitions which may ſometimes be of good and neceſſary uſe in it.

The Rumb and Difference of Latitude given, to find by the Table, the Diſtance in the Rumb, and the Departure from the Meridian thereto anſwerable, &c.

HOw to find the Northing or Southing, that is, the Diſtance in Latitude; as alſo the Eaſting or Weſting, that is, the diſtance in Longitude, or departure from the Meridian of any Rumb, for any diſtance run upon it, we have before ſhewed; the Operation is in theſe Propoſitions following; namely,

2. *The Rumb and Diſtance in Latitude given: to find the Diſtance in the Rumb, and the Eaſting or Weſting.*

3. *The Diſtance and Difference in Latitude given: to find the Departure from the Meridian, and the Rumb.*

4. *The Difference in Latitude, and Departure from the Meridian given: to find Courſe and Diſtance.*

5. *The Course and Departure from the Meridian given: to find the difference of Latitude and Distance.*

6. *The Distance and Departure from the Meridian given: to find the Course and difference of Latitude.*

So that with the first before-handled, here are six Propositions, and in every one of them two things required; and so they become twelve. We will not stand to give Examples of them all, but only of those which are most useful, the rest may by them be conceived.

And first, to find the Easting or Westing of any Rumb for any difference of Latitude.

Admit a Ship run North-easterly 60 deg. (that is, *N. E.* by *E.* and almost half a Point Easterly) till she have altered the Latitude 42 min. how much is she departed from the Meridian?

I run down the Column under 60 deg. till I find 42 Miles, or 420 tenths, and against it in the adjacent Column I find 728 tenths, that is, almost 73 Miles, which is the Departure from the Meridian to the Eastwards.

If you would also have the Distance upon the Rumb, it is right against these numbers in the Column of Distances, being in this Example 84 Miles.

2 *Example.* But admit she run North easterly 60 deg. till she alter her Latitude 1 deg. 32 min. what is the Easterly distance?

This 1 deg. 32 min. is 92 Miles, or 920 tenths, for which if I look in the Column under 60 deg. I find no number so great, but the greatest number there is 500, which subtracted from 920, there remains 420; therefore in that Column under 60 deg. I look for these two numbers, namely, 500 and 420, and against the first in the adjacent Column I find 866, and against the second 728, which I set against them as above appeareth, and so adding them, I find for this difference of Latitude, the departure from the Meridian to be 159 $\frac{4}{10}$ Miles.

100	500	866
84	420	728
184	920	1594

If further you desire the distance run upon this Rumb, you have it in the Column of Distances, right against the same numbers, as in the Example above appeareth, where being added, it amounts to 184 Miles.

The

The Diſtance and Difference in Latitude given: to find the Rumb and Departure from the Meridian.

ADmit a Ship run upon ſome Rumb between the North and the Eaſt 84 Miles, and then have altered her Latitude 42 min. the Queſtion is, upon what Rumb hath ſhe run, and how many Miles is ſhe to the Eaſtwards in Longitude?

I run croſs the Table towards the right hand, looking in every firſt Column of Diſtances for 84, till I find againſt it in one of the adjacent Columns 420, at the top of which Column over 420, there is 60 deg. ſhewing the Rumb to be North-eaſterly 60 deg. alſo againſt 420 in the adjacent Column I find 728, which ſheweth the diſtance to the Eaſtwards to be almoſt 73 Miles.

2 *Example.* But if the diſtance run be 184 Miles, and the difference of Latitude 1 deg. 32 min. and there be required the Rumb and Diſtance to the Eaſtwards.

Becauſe the Column of Diſtance extends but to 100 Miles, and the diſtance here given is 184 Miles, you may take half thereof, which is 92 Miles, and likewiſe the half of 1 deg. 32 min. which is 46 Miles, or 460 tenths, and then look, as before, where you find 460 againſt 92, for there in the top of the Column you ſhall find the Rumb, which in this Example is 60 deg. ſhewing that the Rumb is from the North Eaſterly 60 deg. and in the adjacent Column againſt 92 and 460, you ſhall find 797, which doubled (becauſe it is for the half) is 1594, ſhewing that the departure from the Meridian to the Eaſtwards is 159 $\frac{4}{10}$ Miles. Theſe and the reſt may alſo be performed by the *Doctrine of Plain Triangles*, as we have formerly ſhewed.

CHAP. XII.

Certain Problems touching Currents.

ALthough the time be already expired which I aſſigned for this Work, and mine own more urgent occaſions call me away, yet ſeeing it is neceſſary in *Navigation* to take notice of Currents, and to make a competent allowance for them; I will briefly ſet down certain *Problems*, ſuch as I have ſometimes thought upon, whereby a man may the better concieve and judge of that allowance, the rather for that I know not any that have handled it.

Firſt then, it is to be concieved, that a Ship or other Veſſel Sailing or Rowing where there is a Current, hath a compound motion ariſing of two different Principles; namely, of the Current and Ships way, ſo that here are three motions to be conſidered, namely, two ſimple, and the third compounded of them. The firſt ſimple motion is that of the Current, whereby it moveth, and is apt to move other things that are in it in the ſame way. The ſecond, of the Ship or Boat, as it moveth by Wind or Oars, or is apt to be moved, if there were no Current. The third, compounded of them, is the Line of the Ships true motion. The firſt, we call the way or motion of the Current; the ſecond, the way, or ſimple motion of the Ship; the third, her compound or true way. The two ſimple motions being either of them according to right Lines, and uniform (as in the *Problems* following we ſuppoſe them to be.) The third alſo, which is compoſed of them, is a right line; for whether the Ship ſail directly oppoſite againſt the Current, or directly with it the ſame way, or whether the one croſs the other at right Angles or at oblique; yet ſtill either motion being direct and uniform, they both together beget a right-lined uniform motion, becauſe the one retaineth to the other the one and the ſame proportion in every Point: And according to theſe grounds we proceed in the *Problem* following, to determine the proportions of every of theſe motions, and the Angles which they make one with another.

1. *Admit*

1. *Admit a Current run East 3 Miles an hour, and that a Ship under Sail run West directly againſt it 6 Miles an hour in her ſimple motion, what is her true or compound motion?*

From the Ships ſimple motion	6 miles
Subtract the Current	3 miles
The Remainder is the Ships true motion	3 miles

So the Ships true way is to the Weſtwards 3 miles an hour.

2. *Admit a Current run West 6 Miles an hour, and that a Ship under Sail run directly againſt it 5 Miles an hour by the Log: what is the Ships compound motion, and which way?*

From the Current being the greater	6 miles
Subtract the Ships ſimple motion	5 miles
There remains the Ships true motion	1 mile

Which 1 mile ſhews, that the Ship by her compound motion falls a-ſtern, that is, moves to the Weſtwards 1 mile an hour.

In the experimental Practice of the two former *Problems*, it may ſeem, that a Ship or Boat ſo ordered, hath alſo a motion to the right hand or to the left; but this comes to paſs, becauſe it is hard, and in a manner impoſſible, to ſtem a Tide or Stream ſo exactly, but that the Ship will ſwerve (or yaw, as they ſay) either to one ſide or to the other.

3. *Admit a Current run East 3 Miles an hour, and that the Ship alſo run East 3 Miles an hour by the Log: what is the Ships true motion?*

To the Ships ſimple motion	3 miles
Add the Current	3 miles
The Sum is the Ships true motion	6 miles

So the Ships compound or true way is 6 miles an hour.

4. *Admit a Current run East 2 Miles an hour, and the Ship South 6 Miles an hour: what is the Ships true motion, and which way?*

In handling of any Art, to avoid circumlocution, there are uſed Terms or Words of Art, ſerving to expreſs briefly the things handled. And foraſmuch as this Subject hath not been formerly handled, nor the Principles or Grounds thereof laid (ſo far as I know) we will add a few ſuch terms as may ſeem moſt neceſſary, expreſſing here what we mean by them. Let

Let the Line *AB* run from *A* to the Southwards, and *BD* from *B* to the Eaſtwards, and let *AB* be in proportion to *BD*, as 6 to 2, or 3 to 1.

Then doth *AB* repreſent the line of the Ships ſimple motion, *BD* the motion of the Current, and *AD* the compound motion of the Ship.

And *DAB* is the Angle contained between the line of the Ships ſimple motion, and the line of her compound or true motion, which for brevity ſake we will henceforth call the *Angle of Deflection*. Alſo *ADB* is the Angle contained between the line of the Ships compound motion, and the ſet or drift of the Current, which we call the *Angle of Reflection*.

Laſtly, *ABD* is the Angle contained between the line of the Ships ſimple motion, and the ſet of the Current, which we will call the *Angle of Incidence*.

Then for the Rumb, the proportion is thus:

As the ſimple motion	*AB* 6 miles	*co. ar.*	9.2219
Is to the Current	*BD* 2 miles		0.3011
So is *Radius*			
To the Tangent of Deflection	*t DAB* 18 deg. 26 min.		9.5230

So the Rumb upon which the Ship makes her way good is South 18 deg. 26 min. Eaſterly, that is, *S.S.E.* 4 deg. 4 min. Southerly.

2. *For the Ships true way, or compound motion:*

As the Sine of the Deflection	*s DAB* 18 deg. 26 min.	0.5000
To the Current	*DB* 2 miles	0.3011
So *Radius*		
To the true motion	*AD* $6\frac{33}{100}$	0.8011

So the Ships compound motion is $6\frac{33}{100}$ miles hourly, that is $6\frac{1}{3}$ miles almoſt.

5. *A Ship ſails Weſt 5 days together by the* Log 725 *miles, but there is a Current, all this while ſetting to the Southwards* $1\frac{1}{2}$ *miles an hour: I demand how ſhe hath ſailed, and how far?*

The Current ſetting $1\frac{1}{2}$ miles an hour, ſets in 5 days 180 miles: Therefore,

As

As the ſimple motion	*A B* 725 miles	7.1397
Is to the Current	*D B* 180 miles	2.2553
So is *Radius*		
To the Tangent of Deflection	*t D A B* 13 deg. 57 min.	9.3950

For the Diſtance:

As Sine-compl. the Deflection	*sc D A B* 13 deg. 57 min.	0.0130
Is to the ſimple motion	*A B* 725 miles	2.8603
So is *Radius*		
To the compound motion	*A D* 747 miles	2.8733

So the Ships true way is Weſt-ſoutherly 13 deg. 57 min. or South-weſterly 76 deg. 3 min. 747 miles.

6. *A Ship ſails Weſt 5 days together by the* Log 725 *miles, in a Current ſetting to the Southwards, and then finds that ſhe hath altered her Latitude 3 degrees; I demand the motion of the Current, the Rumb and true way of the Ship?*

This Queſtion differeth little from the former, for ſeeing the difference of Latitudes is 3 deg. the motion of the Current is 180 miles: ſo there is given the Ships ſimple motion, and the motion of the Current, as before, *&c.*

7. *A Ship in 6 hours ſails from a certain Cape or Head-land, South 30 miles by the Log, in a Current ſetting Eaſterly, and then obſerving the ſame Cape, he finds that it bears N. N. W. I demand how faſt that Current ſets, and how far ſhe hath ſailed?*

As let a Ship ſail from *A* towards *B* South 30 miles, but by means of the Current, ſhe is driven more Eaſterly, namely to *D*, from whence ſetting the Cape *A*, it is found to bear N. N. W. And ſeeing the Current ſets from *B* towards *D* Eaſterly; therefore the angle of Reflection *B D A* is 6 Points, that is, 67 deg. 30 min. Here then is demanded the diſtance *A D*, and the drift of the Current in that time *B D*.

As the Sine of the angle of Reflection	*s B D A* 67 d. 30 m.	.0344
To the ſimple motion of the Ship	*A B* 30 miles	1.4771
So the Sine of the angle of Deflection	*s D A B* 22 d. 30 m.	9.5736
To the motion of the Current	*B D* 12 $\frac{16}{100}$	1.0851

And

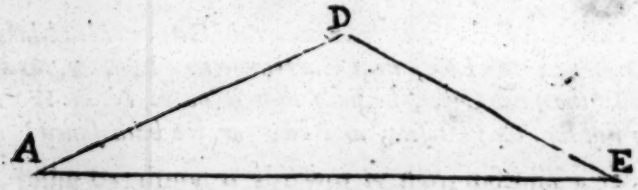
And further,

As the Sine of the Angle of Reflection *s B D A* 67 *d.* 39 m. 0.0344
To the distance run by the *Log A B* 30 miles, 1.4771
So is *Radius*
To the compound motion of the Ship *A D* 32 $\frac{41}{100}$ 1.5115

And thus we find the Current to set 12 $\frac{16}{100}$; that is, near 12 $\frac{1}{6}$ miles in 6 hours, and the distance run to be 32 $\frac{1}{2}$ miles almost.

That the thing may be better concieved, we will use two or three Examples more familiar and obvious to every man's experience; yet grounded upon the same Principles and Reasons.

8. *Admit that* Tulis-stairs *bear from* Billingsgate-stairs *South-west Southerly, namely, South-westerly* 40 *degrees, and be distant* 80 *Poles; and suppose the Tide of Ebb to run there Eastward* 2 $\frac{1}{2}$ *Miles an hour, and that a pair of Oars, rowing* 4 $\frac{1}{2}$ *Miles an hour, would go straight over from the first to the second: How shall they row over, namely, upon what Degree or Point of the Compass, and how far shall they row to get thither, and in what time?*



Let *A* represent *Billingsgate-stairs*, *D Tulis-stairs*, *A E* the simple motion of the Boat, *E D* the motion of the Current, then is *A* the Angle of Deflection, *E* the Angle of Incidence, *D* the Angle of Reflection 130 deg. or 50 deg.

As the simple motion of the Boat *A E* 4 $\frac{1}{2}$ miles 9.34679
Is to the motion of the Tide *D E* 2 $\frac{1}{2}$ miles 0.39794
So is the Sine of Reflection *D s* 50 deg. 9.88425
To the Sine of Deflection *A s* 23 deg. 3 min. 9.62898

Thus then the Position from *A* to *D*, being South-westerly 40 deg. and the Angle of Deflection *A* 23 deg. 3 min. the position from

from *A* towards *E*, is South-westerly 63 deg. 3 min. that is, *W. S. W.* Southerly. And so must those Oars row to go straight over.

Secondly, for the Distance A E.

From the angle of Reflection	*D*	50 deg. 00 min.
Subtract the angle of Deflection	*A*	23 deg. 03 min.
And there rests the angle of Incidence	*E*	26 deg. 57 min.

As the Sine of Incidence	*s E* 26 deg. 57 min.	0.34370
To the true Distance	*A D* 80 Poles	1.90309
So the Sine of Reflection	*s D* 50 deg. 00 min.	9.88425
To the simple motion	*A E* 135 $\frac{3}{10}$ Poles	2.13104

Lastly, for the Time.

Seeing 320 Poles make a Mile, and they row 4 $\frac{1}{2}$ miles an hour, it is 1440 Poles in an hour; so the proportion is,

As the simple hourly motion	1440	6.8416
To the simple motion before found	135 $\frac{3}{10}$	2.1310
So is an hour in minutes, namely,	60 min.	1.7781
To the time required in minutes	5 $\frac{61}{100}$	0.7507

And so long will they be rowing over.

9. *But suppose they will row harder, to go a shorter cut; namely, to go South-west by West: How fast must they go to row straight over, and how far, and in what time?*

Then seeing the Proposition from *A* to *D* is South-westerly 40 deg. and South-west by West is South-westerly 56 deg. 15 min. therefore the angle of Deflection at *A*, is 16 deg. 15 min. the angle of Reflection *D* as before, 50 deg. 00 min. the angle of Incidence *E* is 33 deg. 45 min.

As the Sine of Deflection	*s A* 16 deg. 15 min.	.55311
To the motion of the Tide	*D E* 2 $\frac{1}{2}$ miles	0.39794
So the Sine of the angle of Reflectiou	*D* 50 deg. 0 min.	9.88425
To the simple hourly motion of the Boat	*A E* 6 $\frac{844}{1000}$	0.83530

And such is the hourly motion of the Boat, namely, 6 $\frac{844}{1000}$ miles in an hour.

Secondly, for the ſimple motion.

As the Sine of Incidence	*s E* 33 deg. 45 min.	0.25526
Is to the true diſtance	*A D* 80 Poles	1.90309
So the Sine of Reflection	*D* 50 deg. 00 min.	9.88425
To the ſimple motion	*A E* 110 $\frac{1}{10}$ Poles	2.04260

Thus it appears they muſt row 110 $\frac{1}{10}$ Poles to get over.

Laſtly, for the Time.

The hourly motion before found 6 $\frac{844}{1000}$ reduced into Poles, is		2190 $\frac{1}{10}$
As the ſimple hourly motion	2190	6.65956
Is in proportion to an hour, or	60 min.	1.77815
So is the ſimple motion before found	110 $\frac{1}{10}$	2.04260
To the time required	3 $\frac{0233}{1000}$ min.	0.48031

And ſo long they will be Rowing over.

10. *But admit a Sculler rowing 3 miles an hour, would croſs ſtraight over at the ſame time, upon what Point muſt he row, and how far to get thither, and in what time will he do it?*

Firſt, for the Angle of Poſition.

As the hourly motion of the Boat	*A E* 3 miles	9.52288
To the Sine of Reflection	*D s* 50 deg.	9.88425
So is the hourly motion of the Stream	*D E* 2 $\frac{1}{2}$ min.	0.39704
To the Sine of Deflection	*A s* 39 deg. 40 min.	9.80507

Now ſeeing the poſition from *Billingſgate* to *Tulis-ſtairs*, namely from *A* to *D*, is by ſuppoſition to the Weſtwards of the South 40 deg. and the angle of Deflection *A* is here found to be 39 d. 40 m. therefore the poſition from *A* to *E* is from the South to the Weſtwards 79 deg. 40 min. which is *W.* and by *S.* and almoſt 1 deg. Weſterly, and ſo muſt that Sculler row to go ſtraight over.

Secondly, for the Diſtance A E.

From the angle of Reflection	*D*	50 deg. 00 min.
Subtracting the angle of Deflection	*A*	39 deg. 40 min.
There reſts the angle of Incidence	*E*	10 deg. 20 min.
As the Sine of Incidence	*s E* 10 deg. 20 min.	.74624
To the true diſtance	*A D* 80 Poles	1.90309
So is the Sine of Reflection	*s D* 50 deg. 00 min.	9.88425
To the ſimple motion	*A E* 341 $\frac{6}{10}$ p.	2.53358

And

And thus it appears, that though the diſtance of the two places be but 80 Poles, yet if according to the Queſtion, he row but after 3 miles an hour, and the Stream ſet after $2\frac{1}{2}$ miles an hour, then he muſt row $341\frac{6}{10}$ Poles to go ſtraight over.

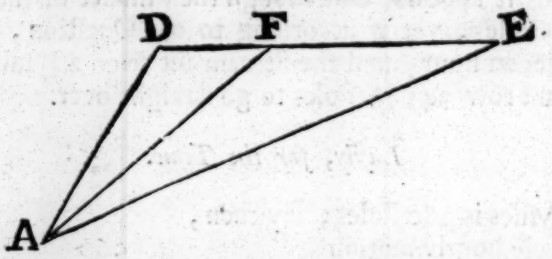
Laſtly, for the Time.

Three Miles is 960 Poles; ſay then,		
As the ſimple hourly motion	960	7.01773
To the ſimple motion before found	$341\frac{6}{10}$	2.53358
So is an hour in minutes, namely	60 min.	1.77815
To the time required in minutes	$21\frac{21}{100}$	1.32946

And thus it appears, that the time requiſite to row over, rowing 3 miles an hour, is $21\frac{21}{100}$ minutes; whereas we found before, that rowing there $4\frac{1}{2}$ miles an hour, they might row over in $5\frac{62}{100}$ minutes, which is little more than a fourth part of the time.

There might be other, and that great variety of Queſtions of this nature propoſed and reſolved, many of good uſe in practice, which the Water-man by daily experience without other Rules, are able to gueſs at ſomething nearly, ſufficing for their occaſions: My intent in theſe is eſpecially to explicate the Compound motion of a Ship, or other Veſſel, Sailing or Rowing where there is a Current; which by ſuch familiar Examples may ſeem more evident. I cannot inſiſt upon them by reaſon of my other occaſions, nor ſpend that time in theſe here handled, which elſe I ſhould have done; whence if any defect or miſtake ſhould ariſe, if the Reader be pleaſed to give me friendly notice of it, I ſhall as thankfully accept it, and reform it. We purpoſe next a Queſtion at Sea, which let be this,

11. *There is a Current at Sea ſetting Eaſt* 12 *miles in* 24 *hours, a Ship ſails in the ſame from a certain Port Weſt South-weſt* 6 *days, and then returning thence, and ſailing North-eaſt and by North* 3 *days, falls with the Port from whence he firſt departed, I demand what his Dead-reckoning was outwards, and what back again, and how far theſe two Ports were aſunder, and upon what Point of the Compaſs?*



As let the Current ſet from *E* towards *D*, and let the firſt Port be *A*, the ſecond *F*, and let the Courſe outward bound be repreſented by *AE*, and the Courſe homewards by *DA*, &c.

And foraſmuch as *DE* is an Eaſt and Weſt Line, and *AE* Weſt South-weſt, therefore the angle at *E* is 22 deg. 30 min, and by the like reaſon, the angle at *D* is 123 deg. 40 min. or 56 deg. 15 min. and the angle at *A* 33 deg. 45 min. and *ED* being the ſetting of the Current for 9 days, is 108 miles.

Firſt then, for the Dead-reckoning outwards, namely, AE.

As the Sine of the angle at *A*	33 deg. 45 min.	.25526
To the Line *DE*	108 miles	2.03342
So is the Sine of the angle *D*	56 deg. 15 min.	9.91985
To to the Line *AE*	74 $\frac{6}{10}$ miles	2.20853

Thus *AE* his Dead-reckoning outwards is 161 $\frac{6}{10}$.

Secondly, for AD.

As the Sine of the angle *DAE*	33 deg. 45 min.	.25526
Is to the Line *DE*	108 miles	2.03342
So is the Sine of the angle *DEA*	22 deg. 30 min.	9.58284
To the Line *AD*	74 $\frac{4}{10}$ miles	1.87152

Which 74 $\frac{4}{10}$ miles is his Dead-reckoning homewards.

Thirdly, for the Angle DAF *or* DFA.

The ſide *AD* is found	74 $\frac{4}{10}$ miles.	
The ſide *DF* for three days is	36 miles.	
The ſum of both is	110 $\frac{4}{10}$.	
Their difference is	38 $\frac{4}{10}$.	
The ſum of the angles *DAF* and *DFA*		56 deg. 15 min.
The half ſum is		28 deg. 7 $\frac{1}{2}$ min.

The

The Proportion.

As the ſum of their ſides	110 $\frac{4}{10}$	7.95703
Is to their difference	38 $\frac{4}{10}$	1.58433
So is the Tangent of	28 deg. 07 $\frac{1}{2}$	9.72706
To the Tangent of	10 deg. 32 min.	9.26932

Which added together, make the angle *D F A* 38 deg. 39 $\frac{1}{2}$.

And ſeeing the Rumb from *F* to *D* is Eaſt, and the angle *D F A* 38 deg. 39 min. $\frac{1}{2}$, therefore the Rumb from *F* to *A* is to the Northwards of the Eaſt 38 deg. 39 min. $\frac{1}{2}$ that is, *N. E* by *E.* almoſt half a Point Northerly, which is the Rumb from the ſecond Port to the firſt.

Laſtly, for A F *the diſtance of theſe two Ports.*

As the Sine of the angle	*D F A s* 38 deg. 39 $\frac{1}{2}$	.20434
To the Dead-reckoning homewards	*A D* 74 $\frac{4}{10}$ miles	1.87152
So is the Sine of the angle	*D s* 56 deg. 15 min.	9.91985
To the Diſtance	*A F* 99 $\frac{1}{100}$ miles	1.99571

Thus the true diſtance of thoſe two Ports is 99 miles, and ſomewhat more.

Sundry other Queſtions of like nature might be propoſed, which to him that well underſtandeth, theſe will not be difficult.

Theſe Principles a little enlarged, may further with a few Experiments be applied in the diſcovery of ſome Myſteries in compound motions, not yet divulged, though much endeavoured by ſundry Famous Men in ſeveral parts of *Europe*; but theſe we ſhall not touch at preſent.

12. *To find where there is a Current at Sea, alſo which way it ſets, and how faſt.*

THis may be done by comparing the Reckonings outwards with the Reckonings homewards, whereof we ſhall give an Example or two.

Firſt, admit a Ship ſail from a certain Port, by one or ſeveral Rumbs or Diſtances, till ſhe arrive at the ſecond, and there find reckoning by Courſe and Diſtance, that ſhe is more Southerly than the Port from which ſhe departed by 541 miles, and more Weſterly by 145 miles: But by his Reckoning homewards, when

when he arrives again at the first place, he finds himself to the Northwards of the second 541 miles, as before, and to the Eastwards 305 miles. Now supposing he were 3 days outwards bound, and 5 days homewards bound, I would know which way the Current sets, and how fast? Here, because the Easterly distance homewards is greater than the Westerly distance outwards, therefore from the Easterly distance 305 miles, subtract the Westerly distance 145 miles, the remainder being 160 miles, is the motion of the Current to the Westwards.

And thus it appears, that the Current sets to the Westwards, 160 miles in 8 days, that is, 20 miles a day, or $\frac{1}{6}$ of a mile every hour.

2 *Example.* Admit a Ship sail from the *Summer-Islands*, by several Rumbs and distances, till she arrive at Cape *Codd* in *New-England*, namely, from the East part of *Summer-Islands*, (the Variation being allowed) first, North 20 miles, and then *N.N.W.* 150 miles; the second day *N.* by *W.* 180 miles; the third day North 90 miles; the fourth day North-east 88 miles, and so arrive at Cape *Codd*: Then by these Courses and Distances we may gather by the foregoing Table, that Cape *Codd* should by this reckoning be to the Northwards 487 Miles: and to the Westwards 30 miles, as here appears.

	North.	*South.*	*East.*	*West.*
North 20 miles	20 0			
North North-west 150 miles	123 6	——	——	57. 4
North by West 180 miles	176 5	——	——	35. 1
North 90 miles	90 0			
North-east 88 miles	62 2	——	62 2	
528 miles	487 3		62 2	92. 5
				62. 2
				30. 3

Now suppose she sail back again from Cape *Codd* towards the *Summer-Islands*, the first day *S. S. W.* 150 miles, the second day *S. S. W.* 160 miles, the third day *S.* by *W.* 130 miles, the fourth day South 140 miles, the fifth day East 110 miles, and so be come again to the East part of the *Summer-Islands*.

South

	North	South.	East.	West.
South S W 150 Miles	——	138. 6	——	57. 4
South S W 160 Miles	——	147. 8	——	61. 3
South by W 130 Miles	——	127. 5	——	25. 3
South 140 Miles	——	140. 0	——	——
East 110 Miles	——	——	110. 0	——
690 Miles,		554. 0	110. 0	144. 0
				110. 0
				34. 0

These Courses and Distances make, as here appeareth, the *Summer-Islands* to be to the Southwards of Cape *Codd* 554 miles, and to the Westwards 30 miles.

Therefore by this last Reckoning back again, Cape *Codd* should be to the Northwards of the *Summer-Islands* 554 miles, and to the Eastwards 34 miles, whereas by the former Reckoning outwards, it was to the Northwards only 487 miles, and to the Westwards 30 miles; so that the difference of these two Reckonings outwards and back again, is 67 miles Northerly, and 64 miles Easterly; which sheweth that the Current in that time, namely, in 9 days, hath set to the Northwards 67 miles, and to the Eastwards 64 miles; that is, North-east a little Northerly, 93 miles, as by the fore-going Table doth appear, which is 10 $\frac{1}{3}$ miles every day.

And what we have here done by the Tables, might have been done (as the fore-going *Problems*) by the *Doctrine of Plain Triangles*.

FINIS.

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